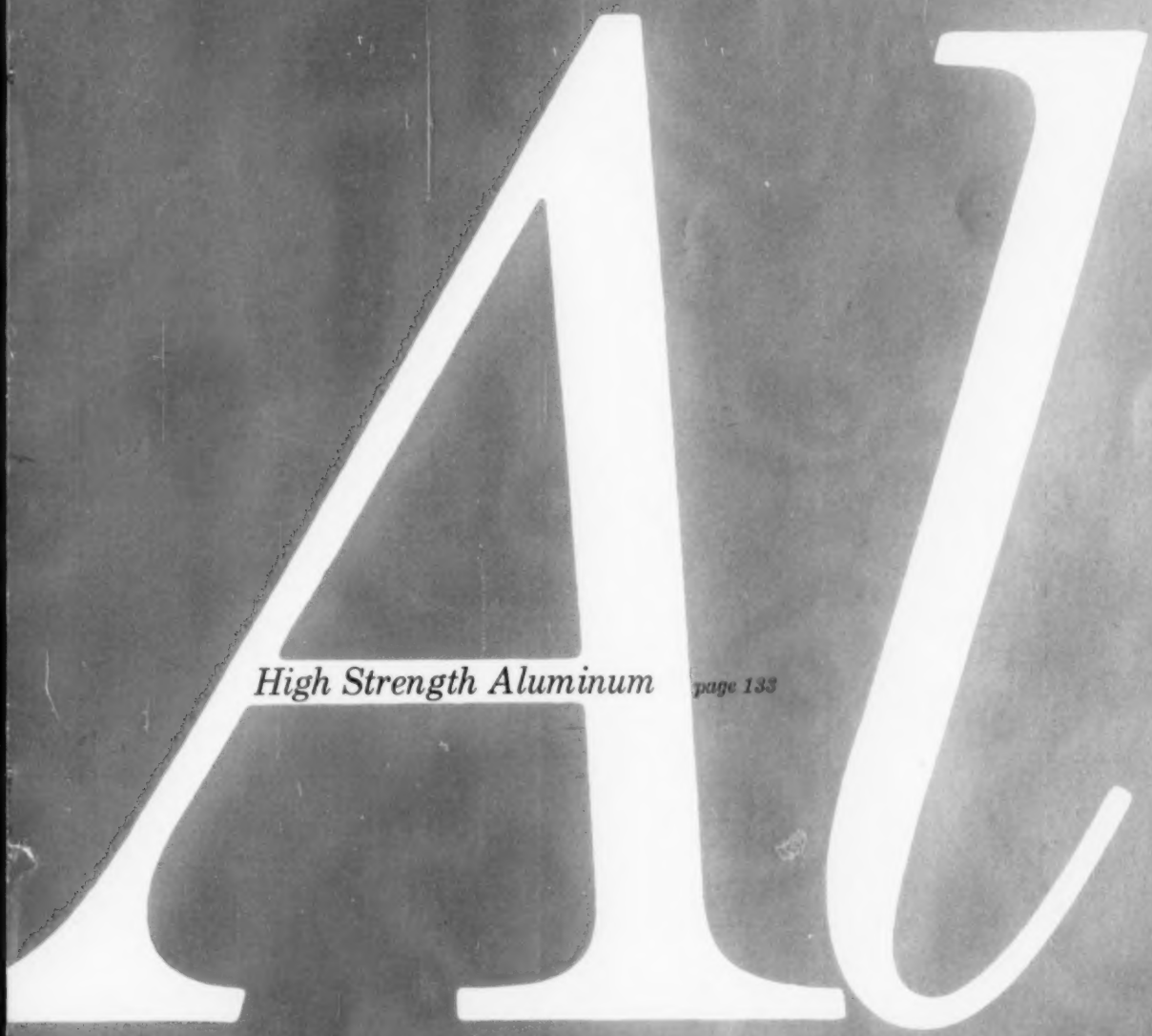
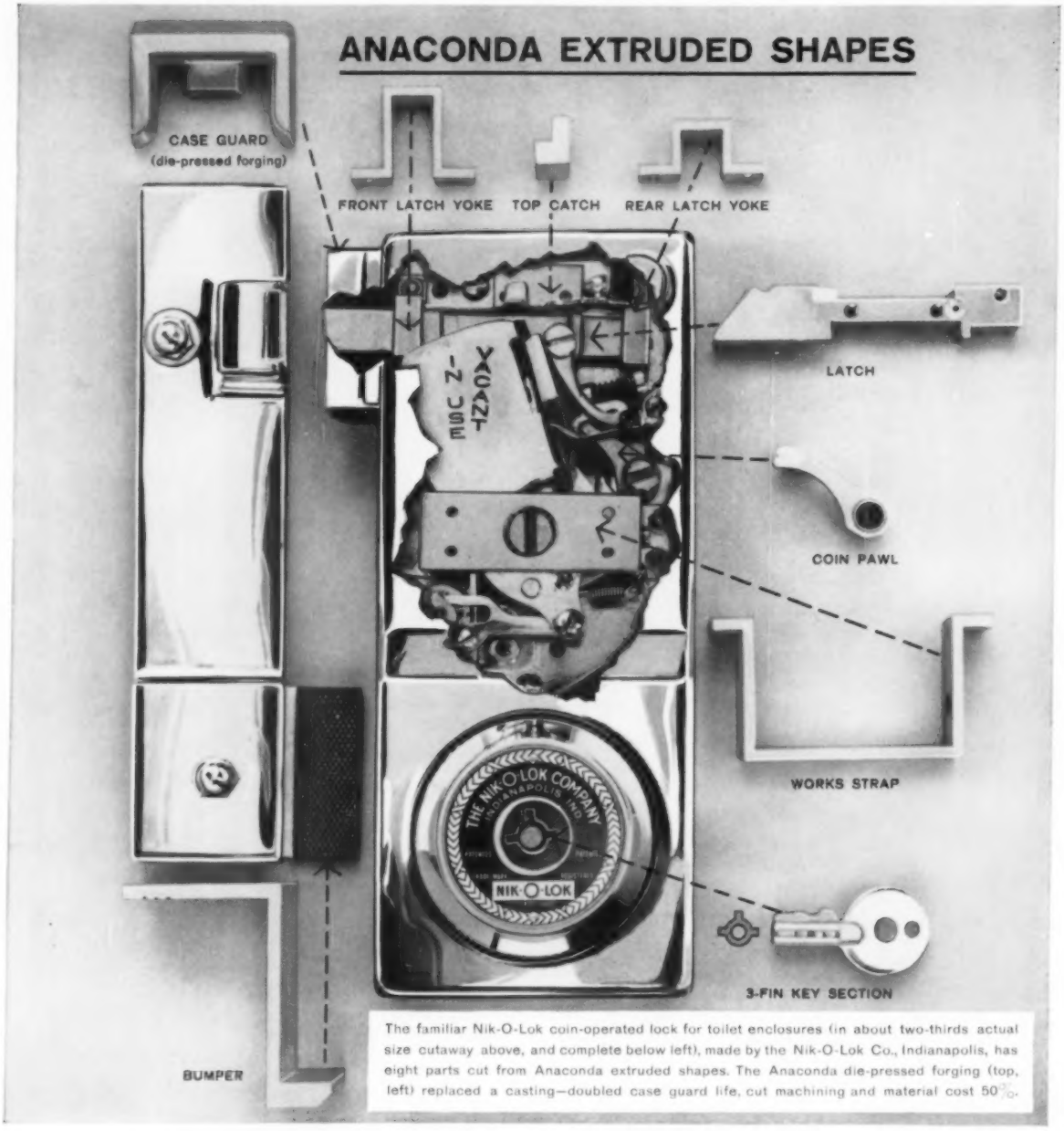
Materials
in Design Engineering



High Strength Aluminum *page 133*

Complete Contents—page 1 | Powder Metallurgy: The Five Trends Today—page 111. Show Preview—page 57

APRIL, 1961



The familiar Nik-O-Lok coin-operated lock for toilet enclosures (in about two-thirds actual size cutaway above, and complete below left), made by the Nik-O-Lok Co., Indianapolis, has eight parts cut from Anaconda extruded shapes. The Anaconda die-pressed forging (top, left) replaced a casting—doubled case guard life, cut machining and material cost 50%.

How parts sliced from long lengths of "premachined" brass shapes cut costs. It starts in design. You select cross sections which minimize subsequent machining—and scrap. The only limitation is that grooves, slots, etc., must parallel the axis of the extruded bar. The smooth surface of extruded shapes reduces many finishing operations. And high dimensional accuracy simplifies assembly. In addition, you get superior, long-wearing parts that improve the quality of your product, because of the strong, homogeneous wrought-metal structure of extruded shapes. For imaginative and practical help in adapting extruded shapes to the economical production of intricate parts, see your Anaconda representative. Or write: Anaconda American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

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APRIL, 1961 | VOL. 53, NO. 4

Materials in Design Engineering®

FORMERLY MATERIALS & METHODS

APPLICATION OF METALS, NONMETALLICS, FORMS, FINISHES

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What's New in Materials

At a Glance 5

'Tailored' Grain Size in Castings 9
Grain size varied in critical areas to give needed properties

Low Cost Way to Coat Pipe 10
Powder process applies thick thermoplastic coating quickly

New Acetal Plastic for Strong, Tough Parts 12
Copolymer said to have improved moldability, heat resistance

Fiber-Reinforced Ceramics for Radomes 14
These refractories are molded much like reinforced plastics

Tool Steel Combines High Strength, Shock Resistance 17
Current uses: hobs, heavy duty punches, mandrels, gun barrels

Fiber Metal Seals Take 5000 Psi, 1200 F 17
Hard metal fiber structure is impregnated with softer metal

What's New in Plastics 19
Materials and processes . . . a report on two national meetings

Other Contents 21

Preview: Powder Metallurgy Show 57
Technical program, exhibitors, registration information for MPIF annual meeting and industry show, Apr 24-26

Materials Engineering & Design

At a Glance 109

The Five Trends in Powder Metallurgy Today 111
Prealloyed powders . . . larger parts . . . composite structures

Plastics Man Is Radiation Guinea Pig 116
Life-size manikin of butyrate used in radiological studies

Materials Engineers Help Build Farm, Construction Equipment 117
In these two industries materials engineering plays a big role

Two New Dashboards 123
A one-piece zinc die casting . . . a molded ABS instrument panel

How Good Are Environmental Tests for Elastomers? 124
Results of accelerated tests can seldom be correlated with service

Introduction to Chemical Milling 128
Materials, sizes, tolerances, radii, undercuts, special contours

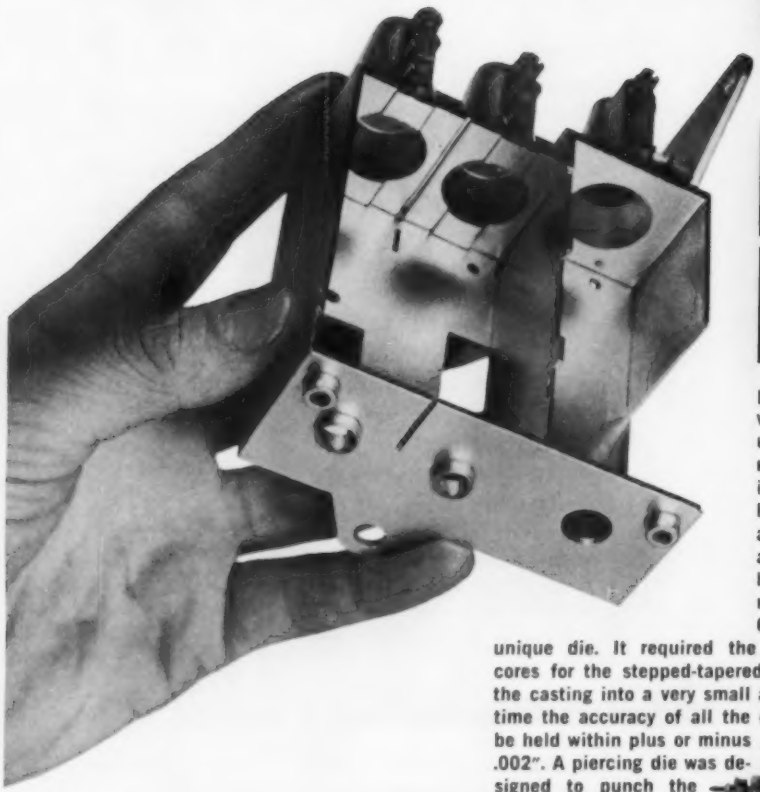
Other Contents 132

SPECIAL REPORT NO. 182

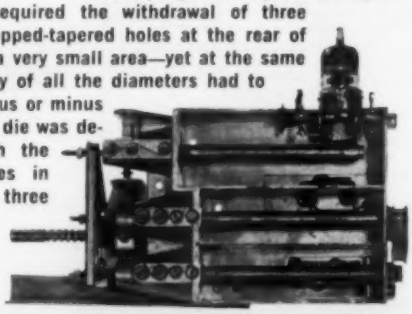
High Strength Aluminum: Where It Stands Today 133
Strong alloys are beginning to find non-aircraft uses

CONTINUED ON PAGE 3 →

HOW eLSe WOULD YOU MAKE IT?



■ Supplying this Motorola television tuner housing on a volume basis could have been a real production headache—were it not for the crackerjack combination of a die caster's skill and Zamak. With the performance virtues of these remarkable zinc die casting alloys in mind, Serv-All Tool and Die Company carefully worked up a unique die. It required the withdrawal of three cores for the stepped-tapered holes at the rear of the casting into a very small area—yet at the same time the accuracy of all the diameters had to be held within plus or minus .002". A piercing die was designed to punch the quarter-inch holes in the housing's three



MOTOROLA TELEVISION TUNER HOUSING

AWARD OF MERIT

The New Jersey Zinc Company's "Zinc Die Casting of The Year" Competition

"ears" as well as several undercuts impossible to cast. These holes were also held to plus or minus .002". ■ Serv-All knew Zamak could give them the castability they needed, could meet the demanding tolerances, could provide the high-strength, thin-wall sections required, and had the ductility for an accurate, easy piercing operation after casting. They also knew of the overall production economies inherent to Zamak—low die cost, long die life and high production speeds. One other characteristic of Zamak sealed the choice—the wide variety of finishing procedures which can be used. In this case the housing is copper-plated to facilitate soldering.

■ Zamak gives you more for less. How else would you make it?

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CONTINUED FROM PAGE 1

News of Industry

UL Studying Safety of Plastics Appliances 23
Ample Columbium Supply Seen 23
High Temperature Materials Meeting 23
Plastics Growth Rate Down Last Year 25
Coming Meetings 27

Reader Service 43

Technical Literature

Suppliers' New Literature 45
Books 51
Reports 54

File Facts

How Temperature Affects Modulus of 16 Alloys 143

Prices & Supply

At a Glance 145

The Last Word

What's Anybody's Business Is Nobody's Business 200

Other Departments

Letters to the Editor 29
Advertising Indexes:
Products Advertised 197
Advertisers 198

NEXT MONTH

Cut Costs, Improve Quality: M/DE Award Winners Show You How . . . sixteen separate articles describe pace-setting applications of new and old materials in motors, pumps, bearings, many electrical components, vehicles, etc.

Zerolling Boosts Strength of Stainless Sheet

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What's Wrong with Data on Reinforced Plastics

Pressure-Tight Aluminum Housings

Epoxy Pellets Speed Encapsulation

Special Show Preview Section . . . Design Engineering Conference and Show plus National Plastics Exposition . . . programs, exhibitors, new products

This Month's Cover: *Design utilizing conventional symbol for aluminum by Harry & Marion Zelenko.*

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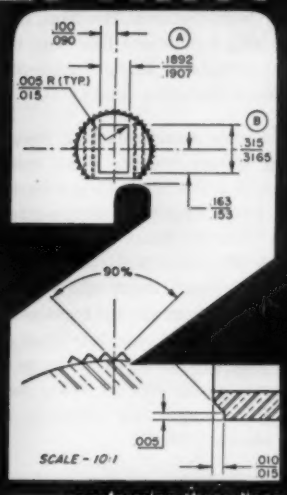

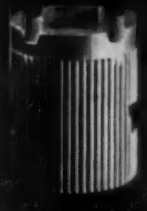

Transforming these lines and numbers into the functional reality of a sintered brass brush holder for small electric actuator motors took teamwork. A design engineer conceived it, and a metal powder fabricator brought it to fruition—at a 65% cost saving over the previous method of manufacture.

It might not have been this way. Despite a design engineer's careful planning, his blueprint could be a neatly drawn recipe for an ulcer – when looked at by a metal powder fabricator aware of the advantages and limitations of his art. Often, a fabricator has little choice but to turn out a part he knows could be made infinitely better—could be made with increased reliability, more wearability, less machining and lower costs.

Working together, the metal powder fabricator and design engineer make economical mass production of critical parts a reality. And we also mean "critical" in the sense that a whole is no better than the quality of its most prosaic part. For more information about the design, application and advantages of nonferrous metal powder parts, write today to The New Jersey Zinc Company for your copy of "Designing For Pressed Brass and Nickel Silver Parts."

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(Advertisement)

How to choose a metal for high-temperature service

In every sense, "the heat's on" and "the pressure's on" when metals go to work at high temperatures. The basic trend in processing equipment has been toward higher pressures, higher temperatures, and more corrosive conditions.

That's why questions like these are being asked today: What metal is used within the core of a gas-cooled reactor where operating temperatures go up to 1700°F? What metal is used for the "skin" of a missile that must take supersonic heats from 400° to 600°F . . . and be the structural framework for 130 tons of dead weight? What metal is used to withstand the corrosion of hot ammonia gas at 900°F? What metal is used for strength and corrosion resistance above 1000°F?

The answer, in each case: Nickel Stainless Steel.

Nickel works as a strengthening and toughening agent. In steel it promotes the formation of austenite, which is stronger and more stable at high temperatures than ferrite. Nickel steps up steel's resistance to oxidation, carburizing, nitriding and thermal fatigue.

The war against corrosion. High-temperature equipment is exposed to a great many different atmospheres and corrosive conditions. Many materials coming from high-temperature processing and handling must be delivered uncontaminated by the products of corrosion. Nickel stainless steels are especially good for fighting corrosion . . . perform well under those oxidizing conditions harmful to unalloyed steel. The stainless steels possess the ability to protect themselves with oxide films that form a shield against corrosion. And *stainless* steel, as the name implies, stays brighter, cleaner . . . and the protective "oxide layer" is less likely to be broken or reduced by pitting or scaling.

What strength means at high temperature. By a mechanism known as "creep" metals at elevated temperatures flow plastically though subjected to stresses below their yield strength, as determined by short-time tensile tests. The creep strength of nickel stainless steels is an important reason for their increasing use in a variety of high-temperature operations. Both *time* and *stress* are design factors at high temperatures. The most generally useful data are those for creep and rupture—one or the other is the basis for most allowable stress values in design work.

The chart below gives the creep and rupture strength data of two nickel stainless steels that have found wide acceptance in high-temperature service:

	CREEP STRENGTH			
	1000°F		1500°F	
AISI TYPE	1% 100,000 hrs, psi	1% 10,000 hrs, psi	1% 100,000 hrs, psi	1% 10,000 hrs, psi
310	17,500	32,500	1,250	3,500
316	14,750	24,500	1,800	4,200
	RUPTURE STRENGTH			
	1000°F		1500°F	
AISI TYPE	100,000 hrs, psi	10,000 hrs, psi	100,000 hrs, psi	10,000 hrs, psi
310	21,000	25,000	1,600	2,800
316	—	—	1,600	3,400

Don't stop at creep and rupture strength . . . other critical questions must be considered in the selection of metals for high-temperature service. They include:

- high temperature ductility
- short-time tensile properties to help evaluate resistance to momentary overloads
- thermal shock resistance

Before selecting a metal for a specific service ask yourself these questions:

- ☐ What is the maximum temperature of operation?
- ☐ What kind of temperature cycling will occur?
- ☐ What maximum load will be encountered? Will it be constant or cyclic?
- ☐ What types of atmosphere or other corrosive conditions?
- ☐ What size or shape of the parts or sections?
- ☐ What further processing will be done, such as welding or machining?
- ☐ What abrasive or wear conditions will be encountered?

The nickel stainless steel family can serve you in a wide range of high-temperature operations. That's why it's best to bring your metal problem to Inco's High Temperature Engineering Section. They are fully prepared to give you practical answers on the metal that will work best in your application. A note to Inco will bring you the "High Temperature Worksheet" to guide you in describing your metal problem.

LITERATURE

The publications listed below will provide more detailed information on choosing metals for high-temperature service.

PUBLICATION NUMBER	NAME
A266	Heat Resistant Castings, Corrosion Resistant Castings . . . Their Engineering Properties and Applications
A227	Stainless Steel for Pressure Vessels
	High Temperature Corrosion in Refinery and Petrochemical Service
A164	Thermal Expansion Characteristics of Stainless Steels Between −300°F and 1000°F
A248	Compilations of Chemical Compositions and Rupture Strengths of Super-Strength Alloys

A complete listing of Inco publications and technical bulletins can be obtained by writing for "List A" to:

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A new thermoelectric material is expected to find use in solid state power generators where temperatures up to 2000 F may be encountered. It is made by combining cerium and samarium with sulfur. The new material, still under development, is said to be of considerable significance since it can be operated at higher temperatures than other thermoelectric materials and with better efficiency. (More details in a forthcoming issue.)

Source: F. L. Carter, Westinghouse Electric Corp., Box 2278, Pittsburgh 30.

A clear protective coating for aluminum is said to greatly improve the corrosion resistance of such parts as automotive trim, cabinet fixtures, hardware and storm doors. Described as an amorphous oxide coating, the new finish can be applied to aluminum by spray or immersion techniques in as little time as 5 sec. The coating is said to make an excellent base for clear lacquers and paint.

Source: Parker Rust Proof Co., 2197 E. Milwaukee Ave., Detroit 11.

A new grade of silicone rubber can be bonded directly to steel without the use of a primer; conventional silicones require a primer. The new rubber is expected to find use in shock mounts, oil seals, rolls and other products where high strength, trouble-free bonds are required. It sells for $5.20 per lb in 1000-lb quantities. (More details in a forthcoming issue.)

Source: General Electric Co., Silicone Products Dept., Waterford, N. Y.

A new aluminum alloy for automotive trim has been developed. The alloy has a tensile strength of 35-45,000 psi and a yield strength of 30-40,000 psi. It is said to be especially suited for body side molding and other applications where good dent resistance is a primary consideration.

Source: Kaiser Aluminum & Chemical Corp., 300 Lakeside Dr., Oakland 12, Calif.

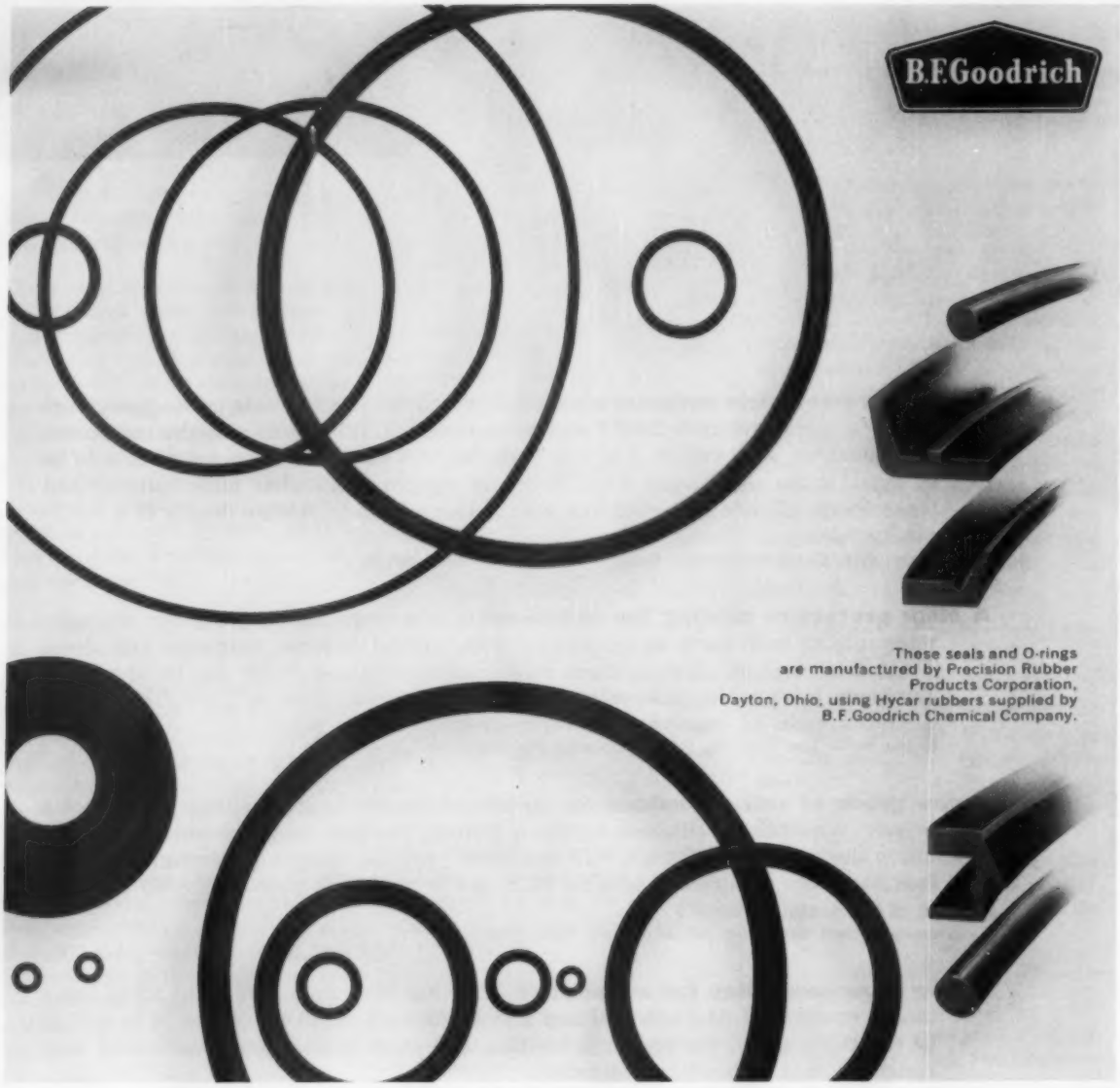
Two new conductive inks for printed circuits are now on the market. One ink is designed for use on porous ceramic boards and the other for polystyrene, acrylic and butyrate plastics boards. Both inks air dry in 35 min.

Source: Advance Process Supply Co., Inc., 2315 W. Huron St., Chicago 12.

Two new metal powders—commercially pure ingot iron, and zirconium with 2% tin—have been added to a line of spherical metal powders introduced last fall (M/DE, Sept '60, p 10). The metal powders are free of such defects as voids, cavities and inclusions. Particle size uniformity is reported to be 98%. (See p 111 of this issue for an article on important trends in powder metallurgy today.)

Source: Crystal Products Dept., Linde Co., 4120 Kennedy Ave., East Chicago, Ind.

A high density polyethylene now available is easier to process than conventional Type III higher density resins. Reason: it is made by a new method which incorporates very-long-chain molecules without altering the resin's processability. Until now, production of resins with a large long-chain content has been impractical,



These seals and O-rings are manufactured by Precision Rubber Products Corporation, Dayton, Ohio, using Hycar rubbers supplied by B.F.Goodrich Chemical Company.

Hycar puts a halter on hydrocarbons ...in seals that take many shapes

Sealing fluids in auto engines, transmissions and power steering assemblies calls for dependable rubber. That's why the manufacturer of these seals and O-rings makes them of rugged Hycar special-purpose rubber.

Hycar nitrile and polyacrylic rubbers are effective in low-swell and high-swell oils, gasoline, fuel oils, hydraulic fluids and sulfur-bearing lubricants. Hycar retains its effectiveness at high or low temperatures.

The wide variety of Hycar rubbers lets you make parts that are effective over a broad range of service conditions. To get more information about how you can use Hycar, write Department MI-2, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical
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Hycar
Rubber and Latex

For more information, turn to Reader Service card, circle No. 393

according to the developer. Pipe made of the New Type III polyethylene resin is said to have better resistance to high pressures and temperatures than ordinary high density polyethylene pipe.
Source: Celanese Corp. of America, 180 Madison Ave., New York 16.

High purity silver for semiconductor applications is now available. Purity is 99.999+%. The metal is supplied in the form of fine crystalline powder, vacuum cast ingots and foil.
Source: High Purity Metals, Inc., 340 Hudson St., Hackensack, N. J.

Improved furane coatings with excellent adhesion to metals have been made by crosslinking furfuryl alcohol resins with polyfunctional amides, amines and amino acids instead of the usual strong acids. The coatings, still under development, are said to have excellent electrical properties and good resistance to acids and alkalis.
Source: E. R. Nielsen, Armour Research Foundation, Illinois Institute of Technology, 35 W. 33rd St., Chicago 17.

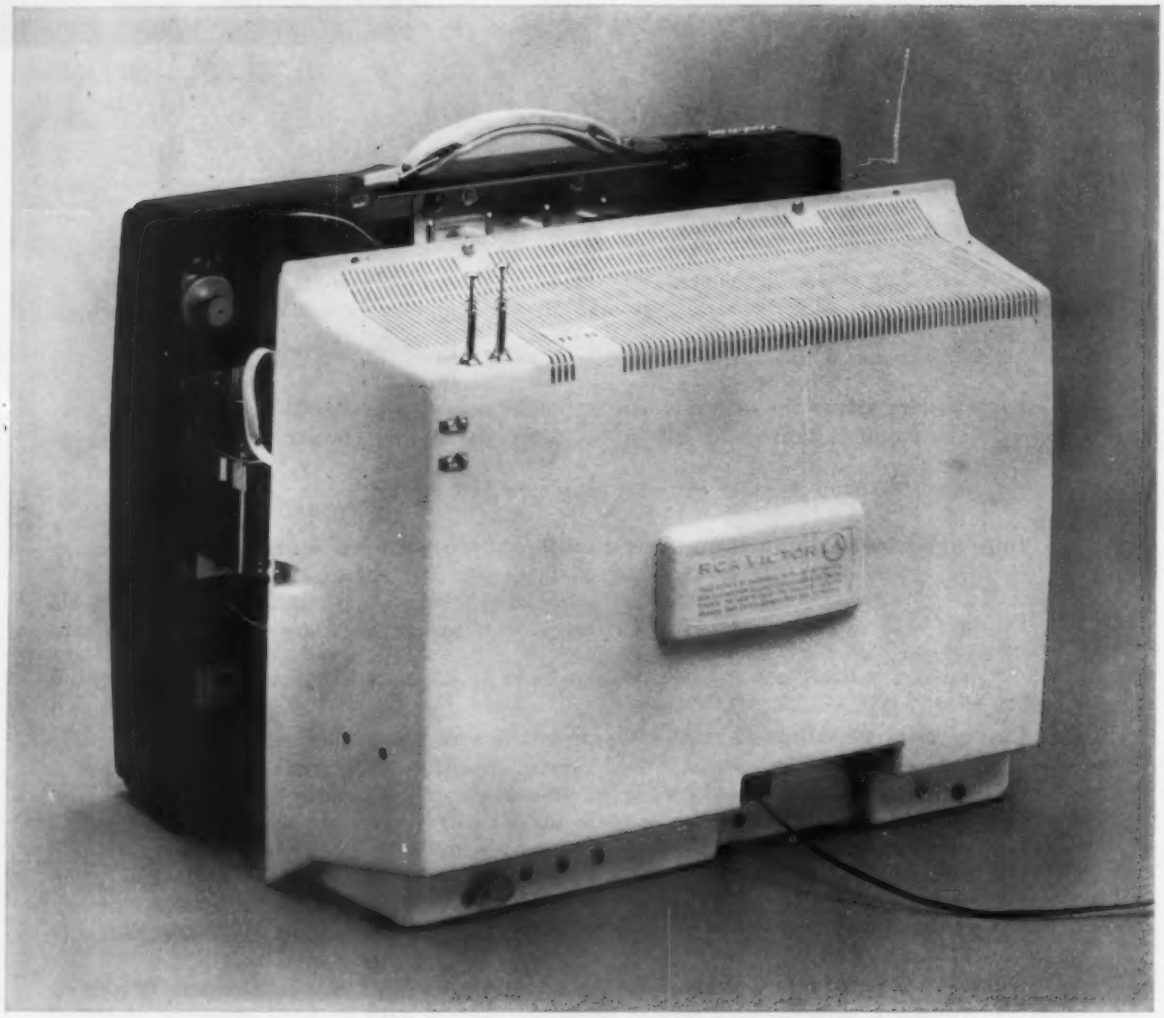
Lower cost titanium castings are promised with the development of a new process for casting small parts in production-lot quantities. The method, details of which have not been revealed, relies on the excellent fluidity of titanium. Previously, titanium had been cast in graphite molds, with production usually limited to one part per mold. So far the developer has produced up to 40 castings per mold and believes at least 100 are probable with the new technique. (More details in a forthcoming issue.)
Source: Titanium Metals Corp. of America, 233 Broadway, New York 7.

Three new reinforced DAP molding compounds have been introduced: 1) a flame resistant, mineral-filled diallyl phthalate that is said to have excellent electrical properties in the presence of high humidity; 2) a mineral-filled diallyl isophthalate that withstands temperatures up to 500 F; and 3) a fiberglass-reinforced compound in the isophthalate group that has excellent electrical properties, high strength and good heat resistance.
Source: Rogers Corp., Rogers, Conn.

Easy-to-solder refractory metal parts for use in electronic and other applications are now available. The parts are vacuum coated with aluminum, nickel or noble metals. The producer says the coatings can be applied in various geometrical patterns to one or both sides of a part.
Source: Vacuum Technology, Inc., 7933 Gloria Ave., Van Nuys, Calif.

New beryllium shear bolts are said to have higher strength-to-weight properties than similar configurations made of steel and titanium. The bolts have 75,000 psi tensile strength, 60,000 psi shear strength and 45,000 psi endurance limit. They are supplied in No. 6 through $\frac{3}{8}$-in. dia sizes. The producer says that a chemical surface finish on the bolts improves ductility and shear strength.
Source: Standard Pressed Steel Co., Jenkintown, Pa.

Turn to page 9 for more "What's New in Materials"



Escon® POLYPROPYLENE
resists heat distortion...at low cost

The backing for this new RCA television receiver is molded of Escon polypropylene in an attractive textured finish. RCA chose Escon because of its high heat deformation point and balance of other important properties. In addition, Escon polypropylene has excellent electrical properties and allows considerable design freedom.

Parts made with Escon polypropylene resist stains and are easy to clean. Colors can be matched easily. Cost of finished parts is lower than those made of any other thermoplastic material that can provide similar properties. For full performance data and complete technical assistance, write to Enjay at 15 West 51st Street, New York 19, New York.

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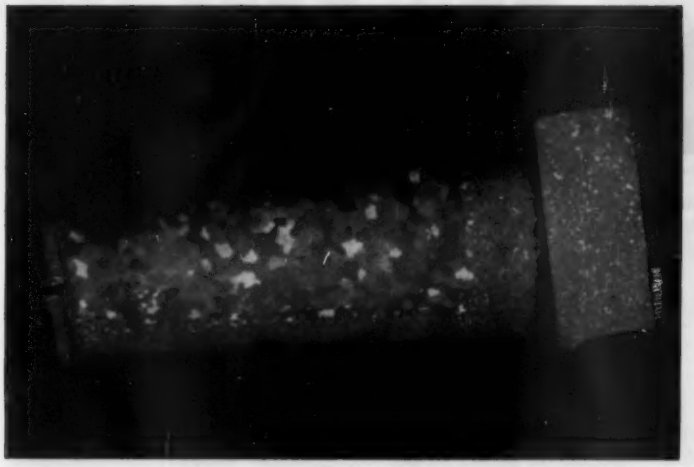
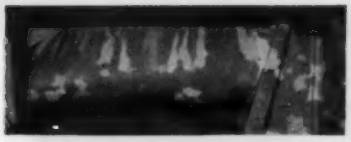




Area control *of grain size (left) puts fine grains (1/64 in. or smaller) at trailing edge of investment cast blade where high tensile strength is needed, keeps larger grains elsewhere for better stress-rupture life. Normal grain size and distribution are shown above.*

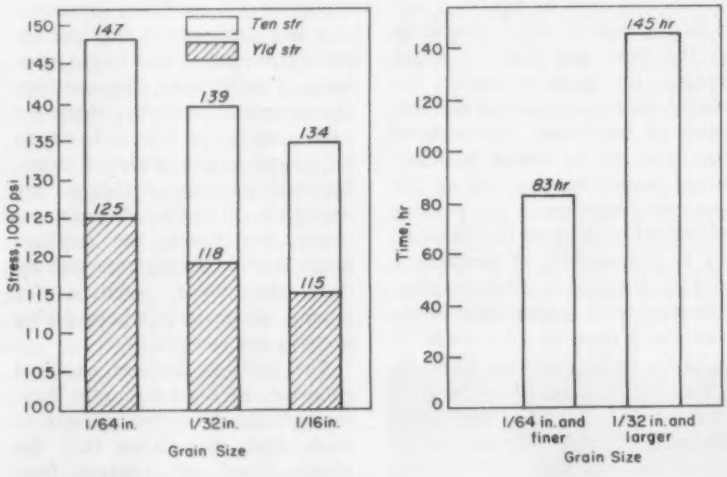
'Tailored' Grain Size

gives needed properties at critical points in castings

■ The blade pictured above demonstrates the kind of precise grain size control that is now possible in investment castings. The techniques, worked out by Haynes-Stellite Co., Kokomo, Ind., have not been disclosed. However, the results are said to be reproducible, and application of the techniques to other casting processes is being explored.

The achievement is of immediate interest to engineers concerned with the service life of investment cast aircraft engine components. The bar charts make clear the importance of grain size control. When superior stress-rupture life is important, you can specify large grains. But where high yield and tensile strengths are needed in a critical area, you can call for smaller grains—all in the same casting.

At the present time, there is no obvious size limitation except the one imposed by the limitations of investment casting. In heavy sections, i.e., over ¼ in., grain size varies through the cross section. Thus a fine-grained structure can be obtained on opposing surfaces but grain size will increase in the center of the section.



Hastelloy 700: as grain size increases . . .

Tensile strength at 1300 F decreases.

Stress-rupture life at 1800 F, 20,000 psi increases.

All photos Hercules Powder Co.

***Interior** is chlorinated polyether (Penton). Most work on new process has been done with this plastic because of its combination of good chemical resistance and relatively low cost.*

Low Cost Way

Powder process applies thick coating quickly . . . . many different thermoplastics can be used

■ An economical new method for coating the inside of metal pipe with a wide variety of thermoplastics has been developed by Engelhard Hanovia, Inc. Because of its inherent advantages—notably low cost—the new method appears to have a broader area of potential use than any other plastic pipe lining method, particularly for use in chemical process equipment.

The process is extremely versatile. Coatings can be deposited in thicknesses from as low as 1 mil to as high as 60 mils, depending on the gage and type of metal treated, the type of plastic deposited, and the time and temperature of treatment. The size of pipe that can be coated is determined mainly by the size of the processing equipment. The present laboratory-scale plant in this country is now capable of handling 2 to 4-in. dia pipe in 20-ft lengths. However, work is underway to extend the process to i.d.'s from ½ to 14 in. and lengths up to 40 ft.

Because of proprietary reasons and pending patents, Engelhard Hanovia will give only limited information on how the process works. After conventional cleaning and surface preparation, the pipe is heated and the coating resin is introduced in powder form. As soon as the powder contacts the metal it fuses to the surface into a continuous layer.

Engelhard does not intend to produce the plastic-lined pipe itself. Rather, the company (located in Newark, N. J.) plans to issue licenses to a limited number of coaters who, because of their favorable geographical location, will be able to offer custom service to nearby users.

Advantages of the process

The new process is quite simple and fast. Coatings are applied in a matter of 6 or 7 sec—considerably less time than is required for other pipe coating and lining processes. Furthermore, the coatings are extremely uniform: thickness variations can be held to less than 5% in any length of pipe. Circumferential thickness variations are negligible. Because of their extreme smoothness, the coatings lower frictional resistance and reduce the power required for pumps, particularly where piping systems are complex.

The coatings possess excellent adhesion and bond strength. Bond strength can be varied and can be made high enough so that the plastic itself will rupture first, leaving the plastic coating still tightly adhering to the metal. Where such high bond strength is not required it is possible to reduce lining cost by producing a less tenacious bond which is sufficiently strong to withstand any differential thermal expansion between the coating and the base metal.

By far the largest cost factors in producing pipe by the new process are the price and amount of plastic resin used. Labor is the second largest cost factor, but because the process can be highly mechanized labor cost is considerably lower than resin cost. In any event, the total cost of pipe made by the new process is much lower than pipe lined with extruded plastic tubing.

Many material combinations

Like any plastic lining process, the new process enables designers to combine the advantages of metals and plastics and at the same time eliminate the drawbacks of each. By using a corrosion resistant plastic over low cost metal, you may be able to dispense with premium pipe materials such as stainless steel and other alloys. To date the coatings have been applied primarily to carbon steel and aluminum (such pipe is expected to be competitive with galvanized steel pipe). However, they can be applied to copper and copper alloy pipe and other corrosion resistant alloys if especially high corrosion resistance is needed.

Almost any thermoplastic can

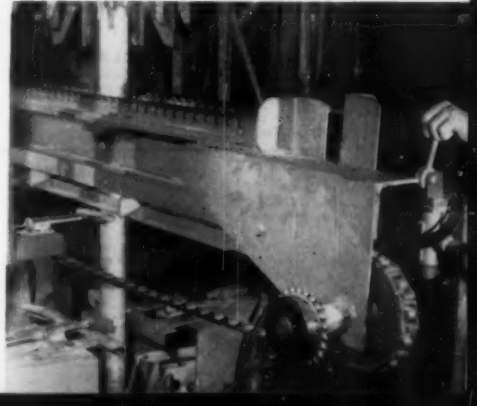
to Coat Pipe

A Three-Step Process:

1 CLEANED . . . *and its surface prepared in conventional chemical bath.*

2 HEATED . . . *in vertical position in 20-ft conveyor oven. By time pipe reaches end of oven it has been brought up to 400 F—the temperature required for fusing the resin powders to the metal.*

3 COATED . . . *still in vertical position at final station at end of oven. Pipe is clamped to end of coating apparatus (not shown) and coating is applied in just 6 or 7 sec.*



be applied by the new process including chlorinated polyether (Penton), nylon, epoxy, the cellulosics, polyethylene and fluorinated ethylene propylene (FEP). Specific cost and performance depend largely on the price and properties of the resin used. Of particular importance is that the new process permits the inside and outside of the pipe to be coated with different plastics, provided that both resins have approximately the same melting point.

Chlorinated polyether first

To date most development has been conducted with chlorinated polyether because of this material's ideal combination of high chemical resistance and relatively low cost. Molded parts of chlorinated polyether have performed very well in the chemical process industries, and the material's chemical resistance and physical properties are essentially the same when it is used as a coating (e.g., see "Fluidized Bed: Heavy Coatings in One Dip," M/DE, Feb '60, p 91, and "Chlorinated Polyether Coating Sprayed on Complex Shapes," M/DE, Sept '60, p 223).

Pipe coated with chlorinated polyether has been successfully tested for over 4000 hr in boiling water with no sign of attack or deterioration of the bond. Similar success has been obtained in rigorous thermal shock tests involving 50 cycles of alternate immersion in boiling water for 4 hr followed by immersion in freezing brine at 6 F for 2 hr.

Potential applications

Major uses for pipe lined by the new process are expected to be in oil, chemical and food processing equipment where the chemical resistance of plastics can provide significant advantages. The pipe is also expected to be useful in paper pulp processing. Finally, there is a possibility that it will be competitive with conventional metal pipe for household plumbing applications.

The process developers expect that pipe lined with chlorinated polyether will be especially useful in medium corrosion applications —the type of applications where Schedule 10 stainless steel is now being used. They also feel that the pipe will be useful in handling potable water, many foodstuffs, and where a low order of corrosion resistance is required, i.e., areas where galvanized pipe and epoxy and phenolic pipe are now being used. They do not expect that the chlorinated polyether-lined pipe will be competitive with Schedule 40 stainless steel pipe in high temperature, high pressure applications where especially high corrosion resistance is required.

For more information Circle No. 602

Excellent moldability, *plus resistance to creep and chemicals are claimed for this newest member of the acetal family of plastics.*

New Acetal Plastic for

The second acetal to be developed, it is said to have improved 1) resistance to cold flow and creep, 2) chemical resistance, and 3) moldability.

■ A new tough thermoplastic, an acetal copolymer, has entered competition for engineered parts requiring strength, heat resistance, good color and gloss.

The new material, called Celcon (pronounced sell'kon), appears similar to the previously available acetal thermoplastic, Du Pont's Delrin. In addition to the superior resistance to creep and chemicals and improved moldability claimed by the producer, short-term ASTM tests show Celcon to have somewhat higher heat resistance than Delrin. Mechanical strength appears to be slightly lower.

The material, developed by Celanese Polymer Co., Div. of Celanese Corp. of America, 180 Madison Ave., New York 16, is currently available in developmental quantities at an introductory price of 70¢ per lb (3.6¢ per cu in.).

The previously available acetal, Delrin, is currently priced at 70¢ per lb (3.5¢ per cu in.). A third acetal is on the way: Heyden Newport Chemical Corp. is reportedly planning to test market its material in early '62.

Major uses for Celcon are expected in decorative and functional parts for autos, machinery gears and bushings, business machine housings and components, communications equipment, and packaging.

TABLE 1—TYPICAL COMPARATIVE PROPERTIES OF CELCON

Material →		Celcon	Acetal[a]	Nylon[b]	ABS (Medium Impact Types)
MECHANICAL PROPERTIES	ASTM				
Tensile Yield Strength, 1000 psi	D638	8.8	10	8.5-9	8.8
Elongation at Yield, %	D638	12	15	60	—
Tensile Mod of Elast, 10^5 psi	D638	3.75	—	1.75	4.0
Flexual Strength, 1000 psi	D790	12	14	14	13.5
Flexual Mod of Elast, 10^5 psi	D790	3.0	4.1	1.75	4.5
Izod Impact Strength, ft-lb/in. notch					
At 73 F	D256	1.1	1.4	2.0	1.5
At −40 F	D256	1.0	1.2	0.5	—
Tabor Abrasion (CS-17 wheel; 1000 gm load), mg/1000 cycles	D1014	14	20	6-8	—
Hardness (Rockwell)	D785	M76	M94	M59	M90
Def under Load (2000 psi, 122 F), %	D621	—[c]	0.5	1.4	0.5
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.41	1.43	1.14	1.07
Heat Distortion Temp, F					
At 66 Psi	D648	—	338	360-390	215
At 264 Psi	D648	230	212	150-170	200-230
Water Absorption (24 hr), %	D570	0.25	0.41	1.5	0.3
Lin Coef of Ther Exp, 10^{-5} per °F	D696	4.5	4.5	5.5	3.2
Mold Shrinkage, in./in.		0.02-0.03	0.02	0.02	—
ELECTRICAL PROPERTIES					
Dielectric Constant					
10^2 Cps	D150	3.8	3.7	—	—
10^3 Cps	D150	3.8	3.7	6.4	3.1
10^4 Cps	D150	3.7	3.7	—	—
Dissipation Factor					
10^2 Cps	D150	0.005	0.004	—	—
10^3 Cps	D150	0.004	0.004	0.02	0.005
10^4 Cps	D150	0.004	0.004	—	—
Volume Resistivity, ohm-cm	D257	1×10^{13}	6×10^{14}	4.5×10^{13}	2.7×10^{16}
Dielectric Strength (short time), v/mil	D149	1200[d]	500	385	385
COST					
¢/Lb		70[e]	65	98	49
¢/Cu In.		3.6	3.5	4.0	1.8

[a]Du Pont's Delrin.
[b]Type 6/6 nylon at 2.5% moisture content, i.e., equilibrium in air.
[c]Specific verified value unavailable; Celanese estimates that deformation should be approximately 15% greater than that of Delrin.
[d]8-mil specimen.
[e]Introductory price

How Celcon compares

Both Celanese and Du Pont have indicated that a major use of acetal plastics will be the replacement of metals where the higher strengths of metals are not required and costly finishing and assembly operations can be eliminated.

But from the standpoint of physical properties alone, Celcon will probably be most competitive with the previously available acetal, nylon and ABS (acrylonitrile-butadiene-styrene) plastics. Table 1 compares short term physical properties of these three mate-

Strong, Tough Parts

rials. Judged by such static properties, Celcon appears to be quite similar to Delrin. Delrin appears to have somewhat greater strength and rigidity; Celcon has the advantage in heat resistance, as measured by heat distortion temperature. Short-term data such as these should only be used for preliminary comparative screening.

Long term performance good

Unfortunately, due to dissimilarities in test conditions, present data on long-term load-carrying ability cannot be compared directly. Fig 1 provides some comparison of apparent flexural modulus of Celcon with that of Delrin, nylon, medium impact grades of ABS, and polycarbonate. The data are from different sources and in most cases stress levels differ, making direct comparison impossible. However, the Du Pont data on Delrin, taken at 1500 psi stress, appear to contradict the Celanese claim to superior cold flow resistance. At this early stage of evaluation no conclusive results can be drawn. Further objective evaluation is needed.

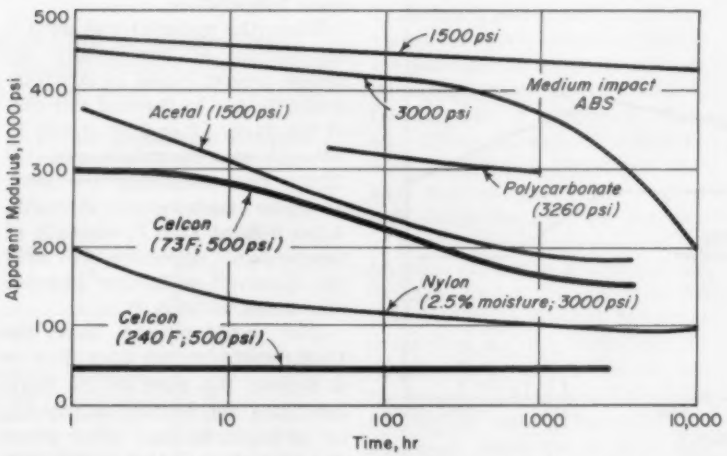
Fig 2 shows flexural creep of Celcon at both room temperature and 240 F. Most deflection occurs during the first hour under continuous loading. The small slope of the curves with time to almost 10,000 hr indicates the material's good resistance to creep.

Fig 3 shows stress relaxation under various initial loadings. The curves show that when a constant strain is maintained, stress relaxes initially (in the first hour), then levels off with only slight subsequent relaxation.

Chemical resistance

Table 2 lists effects of immersion in various reagents for one month at both room temperature and 158 F. According to Celanese, Celcon is unaffected by washing in common solvents such as acetone, ethyl alcohol and lacquer solvents at room temperature. Except for slight color change, it resists strong alkalis even at temperatures of 158 F.

The material is resistant to many dilute acids at room temperatures but is attacked by strong acids. After three-month immersion tests at room temperature in various water solutions having pH values of 4 through 11, the material is said to retain a high proportion of initial strength and stiffness.



1—Apparent flexural modulus of Celcon under 500 psi load at two temperatures compared with other materials at various stresses.

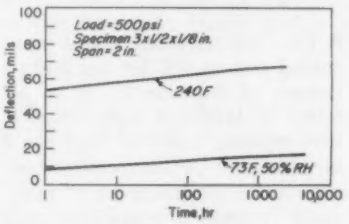
Molding, fabrication

The new material, said to be easily moldable, can be formed by conventional injection or blow molding methods or by extrusion.

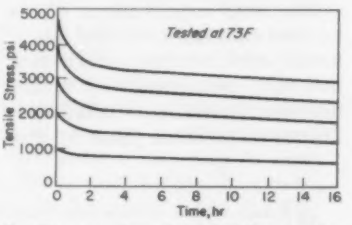
Celcon can be sawed, drilled, buffed, polished and otherwise machined using tools and speeds similar to those used for brass.

The material can be finished with paints and inks appplied by spraying, silk screening or by offset techniques. Variation in the degree of adhesion obtained with various systems suggests that sample trials be made to determine whether adhesion is sufficient for specific applications.

For more information Circle No. 603



2—Flexural creep under 500 psi stress at two temperatures.



3—Stress relaxation of Celcon under constant strain at five initial loads.

TABLE 2—CHEMICAL RESISTANCE
(Appearance after 1-Month Immersion)

Reagent	At 73 F	At 158 F
Water	No Change	No Change
Carbon Tetrachloride	No Change	No Change
Acetone	No Change	No Change
Toluene	No Change	No Change
Alcohol	No Change	No Change
Gasoline	No Change	No Change
Grease	No Change	No Change
Ethers	No Change	No Change
NaOH (10%)	No Change	Discolored
H_2SO 3%	No Change	Severe Cracking
H_2SO 30%	Disintegrated	Disintegrated
HNO_3 (10%)	Discolored	Disintegrated
HCl (10%)	No Change	Disintegrated

Problem: Develop a high temperature material that 1) has the physical and electrical properties of reinforced plastics, and 2) can be processed by low pressure, low temperature techniques similar to those used for reinforced plastics.

Results to date: An inorganic materials system based on aluminum phosphate and fused silica fibers processed by low pressure techniques and cured at temperatures less than 600 F. It retains 8000-9000 psi flexural strength after aging 6 hr at 1300 F.

Fiber-Reinforced

are still developmental but look promising for high temperature radomes. Goal: a radar-transparent refractory that is more like a reinforced plastic.

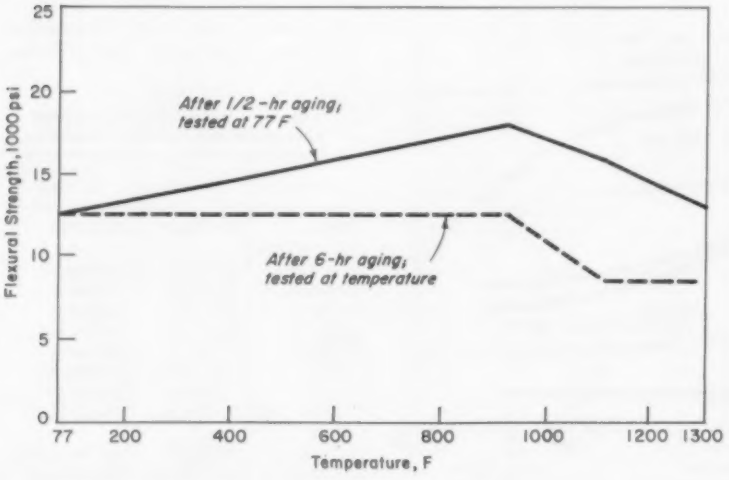
by H. T. Plant, R. T. Girard, and H. R. Wisely,
General Engineering Laboratory, General Electric Co.

■ The requirements above were spelled out to GE by the Navy's Bureau of Aeronautics in an attempt to develop a high temperature radome material that could be processed on inexpensive tooling. Although strengths of materials systems developed to date are still relatively low, the results are promising. Much work remains to be done.

Electrical requirements of the radome material precluded use of metal reinforcement; high temperature requirements further narrowed selection of reinforcing fiber to fused silica (quartz). Previous experience, coupled with low-temperature-curing requirements, centered investigations around phosphate binder systems.

Filament winding techniques were used because at the time the work was started the fused silica fibers were unavailable as woven cloth. Also, this technique eliminated need for final machining, and allowed us to study the effects of pretensioning the reinforcement.

Present cure times are relatively long: 7 days at 175 F, 3 days at 300 F, and a final ½ hr at 570 F. At present, this amount of time is required to achieve cure at low temperatures. Further work should reduce cure time significantly.



1—Effect of heat and heat aging on flexural strength.

Strength retention good

Initial flexural strengths or about 10,000-15,000 psi, though low in comparison with strengths of reinforced plastics, are retained well on aging at elevated temperatures.

Fig 1 shows flexural strength vs temperature, measured at both room temperature and aging temperature. Strength improved after ½-hr aging at 930 F but dropped off after ½-hr aging at 1100 F. Although strength decreased further after aging at 1300 F, it remained superior to strength at room temperature.

When the material was aged 6 hr, testing at temperature revealed greater losses in strength, evidently due to thermal attrition of the yarn. After 6 hr at 930 F, strength at temperature was still 12,600 psi—essentially the same as room temperature strength. After 6 hr at 1100 F, strength at temperature decreased to 8500 psi. However, no further decrease was found at 1300 F.

The data indicate that the binder protected the silica fiber to a degree. The fiber in the laminate does not degrade as rapidly, or as much, as bare silica fibers do. Also, degradation is not continuous but apparently levels off

with time. We feel that with continued aging at 930 F, strength might eventually drop off to the same 8000-9000 psi level exhibited at both 1100 and 1300 F.

Additives improve strength

Addition of various types of inorganic microfibers has provided some substantial improvements in strength. In most cases additions were limited to 3%. Beyond this, increased viscosity of the binder made fabrication of good laminates impossible.

The accompanying table shows effects of adding various types of microfibers. Adding 3% of asbestos floats provides the most significant improvement in room temperature flexural strength, increasing it to nearly 20,000 psi. At 930 F this laminate specimen had lower strength than the others.

Because of the promising room temperature results with asbestos, attempts were made to incorporate more than 3% in the binder. The viscosity problem forced us to remove some of the particulate fillers in the binder in order to introduce an asbestos content of 6%. The resulting laminate was somewhat lower in strength at room temperature, but strength at 930 F was raised to 24,000 psi.

Electricals vs temperature

Because primary uses for these materials would be in high temperature radomes, high frequency dielectric properties were measured. Fig 2 shows effect of temperature on dielectric constant and loss, at a frequency of 9150 mc. Both properties remain relatively constant over a temperature range of 77 to 1100 F. Results were particularly gratifying in light of the relatively poor electrical properties of aluminum phosphate itself.

Although electrical properties are good, porosity of the ceramic leads to instability in the presence of moisture. Reducing porosity of the laminates will require future studies in densification and glazing techniques.

A look to the future

Key to many of the problems in developing improved reinforced ceramic materials is the basic stress-strain relationship of reinforcement and binder.

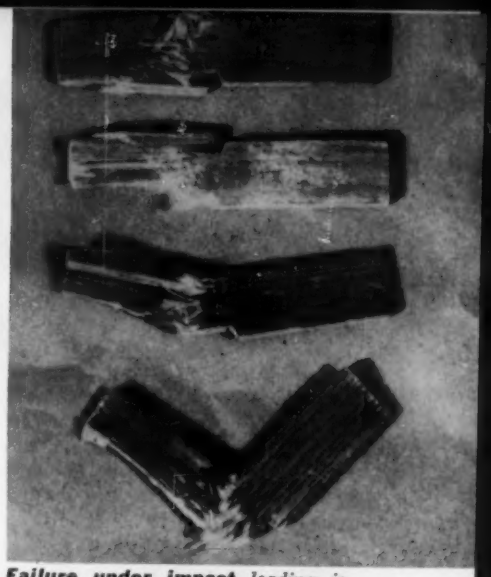
Fig 3 shows idealized tensile stress-strain curves for reinforcement and binder in an inorganic and a plastics system. Several assumptions have been made: 1) tensile strength of glass is assumed to be 400,000 psi, although in practice only about 200,000 psi is usually realized because of damage to fibers during processing; 2) strength and elongation figures shown for current ceramic binders are generous in order to show relationships more clearly; and 3) for the sake of simplicity, chemical attack (a critical problem), fiber lubricity, and effects of heat have been omitted.

Modulus the key—In the case of plastics, the low modulus of the plastics binder is a distinct advantage. As load is applied to the laminate it is divided in direct proportion to the ratio of the moduli of the reinforcement and the binder (if binder and fiber are present in equal volumetric proportions). Since the E glass has a modulus more than 20 times greater than that of the resin, it takes most of the load. The fiber can continue to take an increasing load as the plastics binder elongates. Since the plastic can elongate farther than the reinforcement, the full strength of the reinforcement can be realized—an ideal situation.

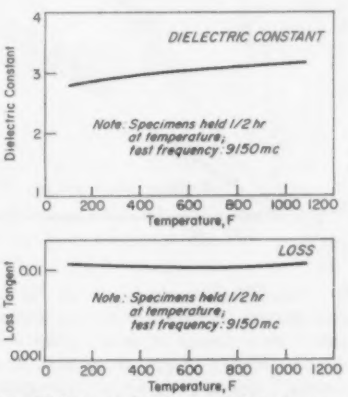
Ceramic binders have low strength and elongation compared to plastics, but ceramics have relatively high moduli of elasticity. In this case high modulus is disadvantageous, as a proportionally larger part of the load is taken by the ceramic binder than in the case of the plastic. Thus, the fiber does not get a chance to do as much reinforcing; only a fraction

EFFECT OF MICROFIBER ADDITION ON LAMINATE STRENGTH

Type of Microfiber ↓	Flexural Strength, 1000 psi	
	At 77 F	At 930 F
None	15.3	17.9
Aluminum Silicate (3%)	14.7	16.4
Potassium Titanate (3%)	14.1	15.2
Calcium Silicate (3%)	16.5	17.0
Silica (3%)	17.5	18.4
Asbestos Floats		
3%	19.9	13.7
6%	19.1	24.0



Failure under impact *loading is surprisingly like that of reinforced plastics, and not at all like that of ceramics. Specimens, though broken, are not totally destroyed.*



***2**—Effect of heat on dielectric constant and loss factor.*

***Air foil** of reinforced ceramic was developed experimentally for Narmco Industries, Inc. It is formed out of silica cloth and ceramic binder.*

of the strength of the reinforcement can be realized.

From these stress-strain relationships, it can be seen that one of two approaches could be used to provide higher strengths in presently developed reinforced ceramic systems: 1) decrease the modulus, or increase the effective elongation, of the ceramic binder, or 2) increase the modulus of the reinforcement.

How to increase elongation—Using the present ceramic materials system, two approaches can be taken to improve the effective elongation of the ceramic binder.

1. Prestress the fiber—Pretensioning the fibers would put the binder under compression so that it must elongate out of compression and into tension before breaking. The effect is that of greater total elongation. Up to now it has not been possible to obtain a significant amount of prestressing because water and other components of the binder attack the fiber.

2. Promote microcracking—A second method of obtaining greater extension of the binder is to promote microcracking. Such cracks must be so small that the specimen does not droop. Actually, we believe that some microcracking has occurred in some of the higher strength (e.g., 15,000 psi) specimens tested.

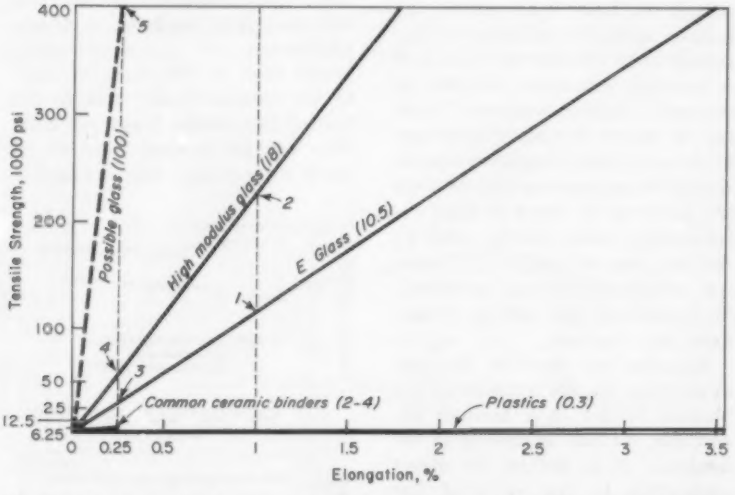
Improved control of cracking could be obtained by using short, fine diameter fibers in the binder matrix. A crack in the matrix would then travel to the fiber and stop.

New fibers or binders—Development of either an extremely high modulus fiber, or a ceramic binder with greater elongation, could also provide substantial improvements in strength.

As can be seen in Fig 3, with present ceramic binders a fiber with a modulus of 100 million psi would be necessary to realize ultimate fiber strength in the composite. This is not likely to be accomplished in the near future.

Alternatively, increasing the elongation of ceramic binders makes it possible to realize greater proportions of the strength of fused silica fibers. Present ceramic binders have elongations in the range of 0.1 to 0.3%. Fig 3 shows that if binders could be developed with only as little as 1% elongation, substantial strength increases would result. With E glass or fused silica fiber, tensile strength of the composite could be increased from a little over 25,000 psi to over 100,000 psi. With the high modulus fiber, even greater strengths could be obtained, but the high modulus fibers presently available are not necessarily heat resistant.

Other problems—Fiber degradation caused by the ceramic matrixes (acidic and basic) studied to date, and by moisture during processing, is as important a problem as the lack of extensibility in the ceramic matrix. One approach to solving the problem is to coat the fibers with protective layers. The problem would be further reduced by developing less corrosive bonding materials.



3—*Tensile stress-strain curves for plastic and ceramic binders, and for several glasses. Figures on curves are modulus of elasticity in 10⁶ psi. Points 1 and 2 show limits of usable fiber strength imposed by presently nonexistent ceramic binder of 1% elongation. Points 3 and 4 show limits of usable fiber strength imposed by limited elongation of present ceramic binders. Point 5 shows limit of possible strength obtainable with a nonexistent extremely high modulus fiber, with present ceramic binders.*

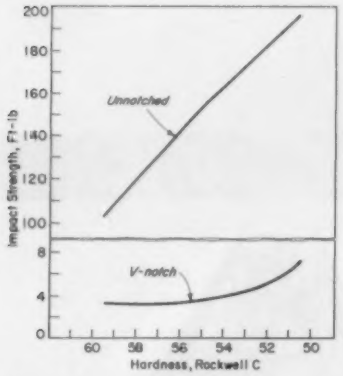
Adapted from a paper presented at the 16th Annual Technical and Management Conference, Reinforced Plastics Div., Society of the Plastics Industry, Inc., Feb '61.

New Tool Steel

Combines High Strength, Shock Resistance

■ An air hardening tool and die steel called Hi Shock 60 has been developed by Carpenter Steel Co., Reading, Pa., for applications that require resistance to extreme shock.

It can also be considered for use as an ultra high strength steel in critically stressed components where a combination of high strength and toughness is required. The alloy is available as bar, billet, wire and strip.



***Charpy and notched impact** values vs hardness.*

Nominal composition (%): 0.68 C, 0.5 Mn, 0.3 Si, 1.0 Cr, 0.5 Ni, 1.0 Mo, 2.5 Cu, 0.15 V.

The high alloy content of the steel permits austenitizing at 1600 F—a relatively low hardening temperature—followed by air cooling. Distortion and residual stresses are thereby minimized. Tempering 1 hr at 300 to 400 F hr offers the best combination of hardness, toughness and mechanical properties with minimum size change. The graphs show how mechanical properties and impact strength vary with hardness.

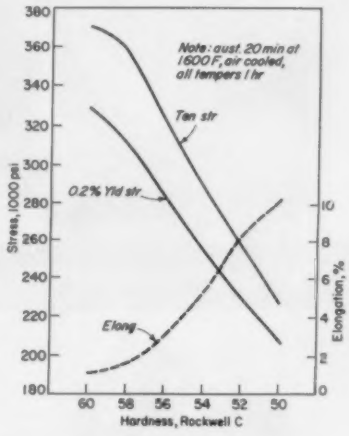
Some details on processing:

1. Forging temperature is 1700 F min, max is 2000 F.

2. Annealing is performed in controlled atmosphere by heating 4-8 hr at 1500-1600 F, cooling quickly in furnace to 1200 F, reheating 4-8 hr at 1350-1375 F, and slowly furnace cooling. Decarburization can be avoided by heat treating in a controlled atmosphere or a neutral salt bath.

3. Stress relieving can be done at 1200-1250 F.

Applications to date include hobs, heavy duty punches, mandrels, gun barrels and cold extrusion punches. The alloy has demonstrated longer service life than other tool steels in such things as coining and embossing dies, shear blades and blade inserts.



***Strength and ductility** vs hardness. Hardness of 60 R, obtained with 1-hr temper at 400 F. (Austenitized at 1600 F for 20 min, air cooled.)*

Fiber Metal Seals Take 5000 Psi, 1200 F

■ Experimental static seals have been made by impregnating strong metal fiber skeletons with soft filler metals. Such seals have withstood pulsating pressures of 5000 psi at temperatures ranging up to 1200 F.

The seals were developed by Armour Research Foundation, 35 W. 33 St., Chicago 16, Ill. under contract to Materials Central, Wright Air Development Div., USAF.

Gaskets, o-rings and v-rings have been tested. Stainless steel and molybdenum have been used for the fiber bodies and silver and magnesium as impregnants. Thus the resiliency of the fiber metal skeleton is combined with the softness and conformability of the filler metal to provide an effective sealing composite.

The seals currently under development utilize corrosion resistant materials and are intended for use with chemicals, exotic fuels or hydraulic fluids.

In a typical series of tests, a v-ring made of molybdenum fibers to 40% skeleton density and impregnated with silver was subjected to 93 hr and 337,000 impulse cycles at 1000 F without resulting in any leakage of a hydraulic fluid. The test included repeated assembly and disassembly, as well as 12 thermal cycles.

NICKELOID IS EVERYWHERE

IN THE LIVING ROOM

IN THE KITCHEN

ALL AROUND THE HOUSE

These eye-catching products use functionally a basic Nickeloid Metal. The finish of Chromium, Nickel, Brass or Copper is electroplated to a base metal, usually Steel (but often Zinc, Brass or Copper).

Mostly, Nickeloid Metals are supplied in continuous coils in widths up to 24" for modern, low cost fabrication. They're also available in sheets and strips. Optional: bright or satin finishes, plating one or both sides, a galaxy of stunning patterns and crimps.

Quality plating produces metals so durable they can be fabricated, even quite severely drawn or bent. Rejects minimized. For severe stamping, we offer Mar-Not protective coating that is easily peeled off after its job is done.

Yes, wherever you go or whatever you do, there is an abundance of useful and prized products on which a Nickeloid Metal gleams, front and center, in full spotlight. Their use at once captures a smart, modern beauty that is durable, easy to keep looking new, and chic. But here is beauty that is more than skin deep . . . Nickeloid Metals are versatile, extremely economical in manufacture . . . deep-down in quality all the way. They are the shopkeeper's delight, the manufacturer's friend, and the designer's inspiration. You can *do so much* with Nickeloid! It's more than a Metal . . . it's a *Method!* Write for free Introductory Kit, including metal samples. Or, phone one of our sales offices (located in most principal cities).

DESIGN ENGINEERING SHOW (BOOTH #1042) COBO HALL, DETROIT, MICH., May 22-25

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What's New in Plastics

New materials . . . new processes . . . new data . . . culled from over 180 papers presented in recent weeks at the annual technical conferences of the two national plastics societies.

Astronaut couch *for the Project Mercury space capsule is made of glass-reinforced polyester and aluminum honeycomb, fabricated by a novel process: aluminum honeycomb is applied to glass-resin layer, internal reinforced plastic skin is applied to honeycomb, and entire structure is bag molded and cured at once. Finished couch is shown at right. Materials selection and design of couch were described by M. Hochberg of McDonnell Aircraft Corp. (SPI)*

by Malcolm W. Riley, *Associate Editor, Materials in Design Engineering*

■ News in plastics is seldom made overnight. Thus, developments reported here are evolutionary, not revolutionary. Initial reports on most of these materials have been published before, but important new data were presented at the recent annual meetings of the Society of Plastics Engineers and the Reinforced Plastics Div. of the Society of the Plastics Industry.

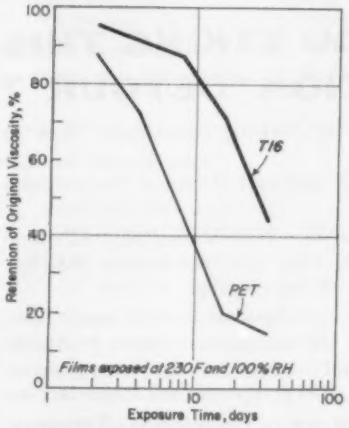
The new data helped to put a number of new materials in better engineering perspective. Among the most important were 1) a polyester film, 2) a high temperature phenolic molding compound, 3) a recently announced family of epoxies (epoxidized polyolefins), 4) two new self-extinguishing materials: an epoxy and a family of polystyrenes, and 5) a recently announced polyvinylidene fluoride.

How new film compares

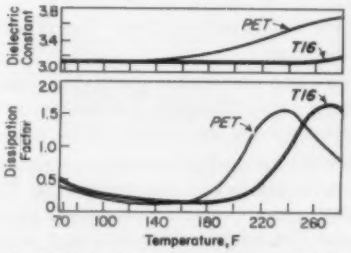
Properties of a new polyester film were compared with those of PET (polyethylene terephthalate) type polyester films (e.g., Du Pont's Mylar) in an excellent paper by M. T. Watson of Tennessee Eastman Co. (SPE).

The new films were made from Eastman's T16 polyester — poly (1,4-cyclohexylenedimethylene terephthalate), the polymer from which Kodel fiber is made. (Properties of Terafilm, a commerical film produced from this material by Acme Backing Corp., were given in M/DE, Jan '61, p 15.)

From the data, T16 appears

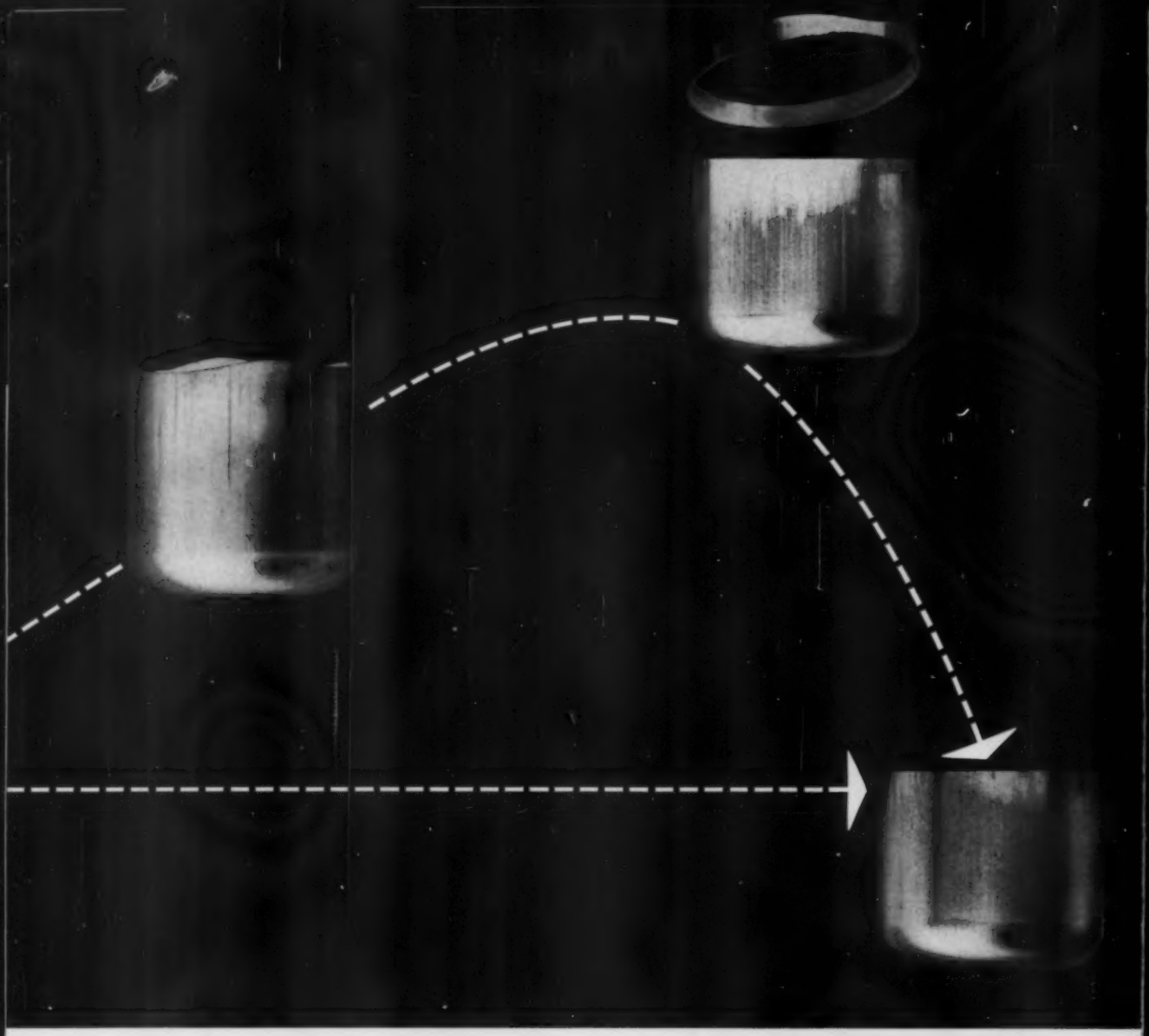


1—Hydrolytic stability of PET film vs new T16 polyester film.



2—Effect of temperature on dielectric constant and loss of PET vs T16 films.

For more information, circle No. 356



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You can do this by specifying J&L Precision Non-Scalloping cold rolled strip steel. Through precise control of every production step, J&L has developed a low carbon strip *which is non-scalloping.*

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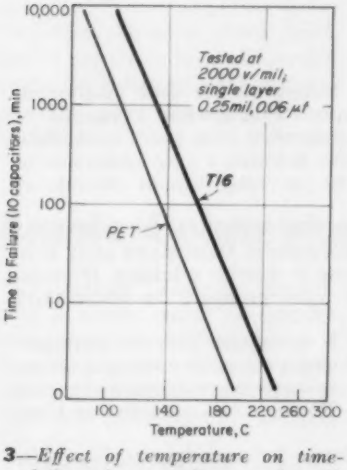
superior to PET films primarily in 1) stability on exposure to water, acids and bases, 2) electrical insulating properties, 3) density, 4) colorability, and 5) in stabilized form, environmental stability. PET films appear superior to the new film in strength and toughness, and environmental stability in the unstabilized form.

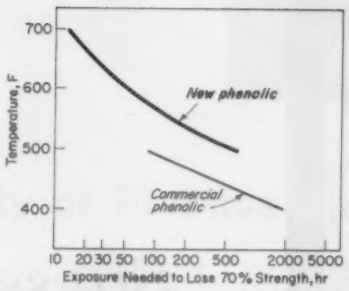
Fig 1-3 compare the two films in hydrolytic stability, dielectric constant and loss vs temperature, and effect of temperature on failure time for capacitors.

New phenolic for 500-600 F

A compression or transfer molding compound developed from a new phenolic resin and designed for long term use in the 500-600 F service temperature range was described by W. G. Colclough, J. Harding and C. Y. Meyers, of Union Carbide Plastics Co. (SPE).



3—Effect of temperature on time-to-failure for capacitors made with PET and T16 films.



4—Aging time and temperature required to lose 70% of initial strength.

In comparative testing, the authors reported, the best commercial phenolic molding compound tested lost 20% of its weight after aging 325 hr at 500 F; the new phenolic required 750 hr aging at 500 F for the same weight loss. Fig 4 shows the longer aging time required at various temperatures to lose 70% of initial strength. Effects of postcure on 500 F fluxural strength are shown in Fig 5. Table 1 shows relatively good retention of electrical properties after heat aging.

Other properties of the new asbestos-filled molding compound, designated BMGA-4127, include a 264-psi-heat distortion temperature above 500 F; flexural modulus of elasticity of 240,000 psi; specific gravity of 1.9; and water absorption (24 hr) of 0.22% by weight.

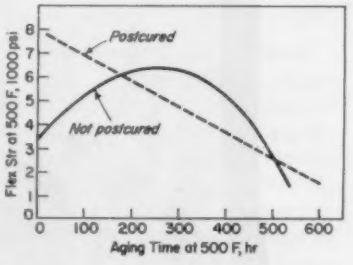
Heat resistance of new epoxy

New data on Oxirons, the epoxidized polyolefin-type epoxy resins announced last year (see M/DE, Apr '60, p 19), centered primarily on heat resistant formulations. Data for both cast specimens and wet and dry lay-up laminates were given by C. W. Johnston and F. P. Greenspan of Food Machinery and Chemical Corp. (SPI).

TABLE 1—EFFECTS OF HEAT AGING ON ELECTRICAL PROPERTIES OF NEW PHENOLIC

Condn →	As Molded	After 400 hr at 500 F	
		Tested at 77 F	Tested at 212 F
Vol Res, meg-ohm-cm	1.6×10^7	4.2×10^5	5.2×10^5
Power Factor			
60 Cps	0.15	0.14	0.13
1 Mc	0.07	0.04	0.02
Dielec Const			
60 Cps	11.4	10.3	8.7
1 Mc	6.3	6.0	—
Dielec Str (s/s), v/mil	310	235	—
Arc Res, sec	196	250	—

Source: Colclough, et al.



5—Effects of post cure on strength retention after high temperature aging.

Unreinforced specimens — The superior heat resistance of Oxiron formulations is shown in Fig 6 in terms of effects of heat on flexural strength and modulus. Specimens were brought to equilibrium for 30 min in an oven at temperature prior to testing. The authors point out, however, that if the conventional epoxy shown for comparison purposes had been a high temperature formulation (e.g., methyl nadic anhydride and benzyldimethylamine) flexural strength at 300 F would have been comparable to that of the Oxiron materials.

Good heat resistance is also shown in Fig 7 by the low rate of stress relaxation of an Oxiron

(continued on page 147)

MORE WHAT'S NEW IN MATERIALS

Contoured woodchip parts 158
Three new adhesives..... 160
Silicone rubber for potting 162
Manganese bronze 164
Synthetic felts are strong, heat resistant 166
Dry-film lubricants 166
Epoxy-glass insulation ... 168
Vinyl coating protects with single layer..... 170
Polyurethane tape 170
Stainless steel resists combustion products ... 172
Coated plastics films are weather resistant... 174
Foam plastics resist oil, gasoline, acids..... 176
Synthetic rubber has good color stability 180
Polystyrene has good impact strength at —20 F..... 182
Rigid foamed plastic resists deformation 182
Other news 184

For more information, circle No. 384

Stress-Corrosion Cracking a Problem?

...Test **HAYNES** Alloys

Highly stressed, in boiling 42 per cent magnesium chloride, for 800 hours! That's what a sample of HASTELLOY alloy F underwent in a test . . . *without cracking!* Similar success followed a long immersion of stressed alloy F in 50 per cent lithium chloride at 325 deg. F.

These and countless other equally tough tests point up the remarkable resistance of HASTELLOY alloy F to stress-corrosion cracking in chloride solutions. If stress-corrosion cracking is your problem, let HASTELLOY alloy F solve it.

HASTELLOY alloy F is one of nine HAYNES corrosion-resistant alloys developed over a 30-year span of intensive concentration on corrosion problems and metals that best resist them. Now you can capitalize on these years of experience.

Send for test samples—Let us help you. Just write us a letter telling as much as possible about the corrosive conditions involved. If you would like more information about the properties and corrosion resistance of HASTELLOY alloy F, ask for a copy of our 12-page booklet. Address inquiries to Haynes Stellite Company, 270 Park Avenue, New York 17, N. Y.

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For more information, turn to Reader Service card, circle No. 426

UL Studying Safety of Plastics Appliances

A three-phase program to discover if plastics in home electrical appliances create fire hazards is now being conducted by Underwriters' Laboratories.

The status and aims of this program were reviewed in a speech by UL's Louis M. Kline at the recent Society of Plastics Engineers Conference in Washington.

Three phase program

After UL caused a storm of protest by severely restricting the use of plastics in electrical appliances two years ago, the Manufacturing Chemists' Assn. initiated a project in which UL would study the safety of plastics in appliances. (For background see M/DE, June '59, p 207; July '59, p 192; Nov '60, p 27.)

According to Kline, the project was planned in three phases: 1) surveying field records to determine the history of plastics as fire and shock hazards; 2) categorizing plastics by their ignition and combustion behavior; and 3) modifying the choice of plastics and electrical components in appliances deemed unsafe.

The following progress was reported for each of the phases:

1. Manufacturers' data and the results of an extensive survey of fire officials, repair shops and extensive press clipping files revealed no incidents pointing to dangerous designs or materials.

2. An advisory committee, selected by UL and MCA, has chosen about 50 molded and foamed plastics for testing. This evaluation has been underway for about a year and is not expected to yield conclusions before the end of 1961.

3. Modification of unacceptable appliances ultimately depends on the completion of the plastics evaluation program, but the modification work will be started soon.

A more fundamental approach

Industry groups and UL are also examining a more fundamental attack on the problem: quickly getting the data on tested plastics to designers so they can select the best materials before production. UL also feels that ways should be found to help designers be better judges of electrical hazards.

Ample Columbium Supply for Growing Demands

Columbium, generally considered a scarce metal, is actually quite plentiful. In fact, it is 1½ times as abundant as lead, according to C. T. Sims, Materials & Processes Laboratory, General Electric Co.

Columbium is rapidly becoming one of the most important refractory metals for aerospace vehicle and nuclear reactor applications.

Fortunately, the largest known ore reserves are in the free world; particularly Brazil, Canada, the United States, central Africa and Norway. These deposits, estimated at seven million tons of metal, are the equivalent of four million tons of mill products.

Price already dropping

Improved extractive and processing methods are providing a greater supply of the metal at lower prices. For example, in 1956 "high purity" sheet cost about $100-$125 per lb. Improved quality metal now costs approximately $35 per lb.

A report by the National Research Council's Materials Advisory Board estimates that a production level of 1000 tons per year could be attained in two years. An output of 10,000 tons per year is possible in two to five years provided pyrochlore ores are exploited more completely, controlled atmosphere rolling mills are developed, and alloy sheet rolling improves.

At such an output level, a price of $5 per lb is predicted. This means that columbium will probably be down to the price level of zirconium and molybdenum ($10-$20 per lb) in a few years.

High Temperature Materials Will Be AIME Topic, Apr 26-27

Materials suitable for applications above 1600 F will be the subject of a conference to be held Apr 26-27, 1961 at the Pick-Carter Hotel, Cleveland.

The conference is sponsored by the Cleveland Section and four other groups of the American Institute of Mining, Metallurgical and Petroleum Engineers.

One of the highlights of the meeting will be a dinner speech on Wednesday night by George M. Low, chief, Manned Space Flight, National Aeronautics and Space Administration. He will describe Project Mercury and the next planned step, Project Apollo

, Allis-Chalmers combines fend off corrosion . . .

GUARDED BY GALVANIZED STEEL

When you see a big Allis-Chalmers combine like this cutting grain on the farmlands of America you can be sure that galvanized steel has been used in its construction.

Reasons? First, galvanized steel provides excellent weather protection and low maintenance cost. Neither dew nor drizzle nor drenching rain will find a chink in its zinc coating. That holds true regardless of the severity of the fabricating steps to which it may be subjected. And in addition to its corrosion resistance, galvanized steel has a lot of resistance to high cost: It's easy and economical to fabricate, construct and maintain.

WEIRKOTE® IN PARTICULAR! The galvanized steel used in these combines is National Steel's Weirkote. To the inherent strength, economy and versatility of steel, Weirkote adds enduring zinc protection via the modern continuous process. As a result, Weirkote can be worked to the very limits of the steel base without chipping or peeling. And it assures you of long-lasting protection against corrosion. It is manufactured by two National Steel Corporation divisions, Weirton Steel and Midwest Steel. Write Weirton Steel Company, Weirton, West Virginia, for further details.

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Three technical sessions will be held on Wednesday, Apr 26, and five on Thursday.

Wednesday — performance requirements for high temperature materials; tungsten, tantalum and their alloys; cobalt and nickel-base alloys.

Thursday—processing and fabrication of refractory metals; molybdenum, columbium and their alloys; fabrication of refractory metals; graphite and refractory compounds; coatings on refractory metals.

NBS Forms Two New Committees

Two new Technical Advisory Committees have been established by the National Bureau of Standards, U. S. Dept. of Commerce, to aid the Bureau in its liaison with industry.

One committee is for Engineering and Related Standards and the other is for Calibration and Measurement Services. Leaders in industrial, scientific and government materials programs will be members of the committees.

Plastics Growth Rate Showed Some Decline in 1960

The overall growth rate of the plastics industry slowed somewhat in 1960, according to R. K. Turner, president of Union Carbide Plastics Co.

Some of the more mature resins showed a sales decrease from their 1959 performance, Turner says. However, the relatively new resins—high density polyethylene and polypropylene—showed marked gains.

"A resin such as phenolic, in commerce now for 50 years, has reached maturity," he continued. "Many of its applications are tied to production of durable goods and capital items, and its fortunes, therefore, are strongly influenced by the economic climate." Neither growth or decline are likely to vary from that of the economy.

He said that certain other plastics seem to have saturated their markets and are greatly affected by economic change. A third group, the major volume resins—polyethylene, vinyl and polystyrene—had a modest growth during the year.

ASM Literature Searching Service Goes Electronic

The information searching service of the American Society for Metals will soon be using a General Electric 225 computer to provide the first operational electronic literature searching service.

ASM's Documentation Service, located at Western Reserve University, says it will be able to immediately provide subscribers with digests of the world's metallurgical literature in their areas of interest.

All digested information is indexed and coded on magnetic tape. Then the computer selects the items of particular interest to each subscriber. He will receive a comprehensive report every two weeks.

ASTM Committees Report on Engineering Materials

More than 1200 engineers and scientists attended the American Society for Testing Materials' Committee Week held recently in Cincinnati.

Virtually all phases of engineering materials specifications and standards were covered in 360 committee sessions.

Radiation effects on metals

The effects of radiation on metals were the subject of two recommended practices presented at the meeting by Committee E-10 on Radioisotopes and Radiation Effects. One is for determining the tensile and impact properties of irradiated metals. The other is for surveillance testing of structural materials in nuclear reactors.

Committee E-10 is a new organization formed to study the effects of radiation on various materials including those operating in space. In its first meeting, held recently in Utica, N. Y., the group agreed to limit its work to natural radiation rather than including the effects of man-made rays.

Other reports of interest

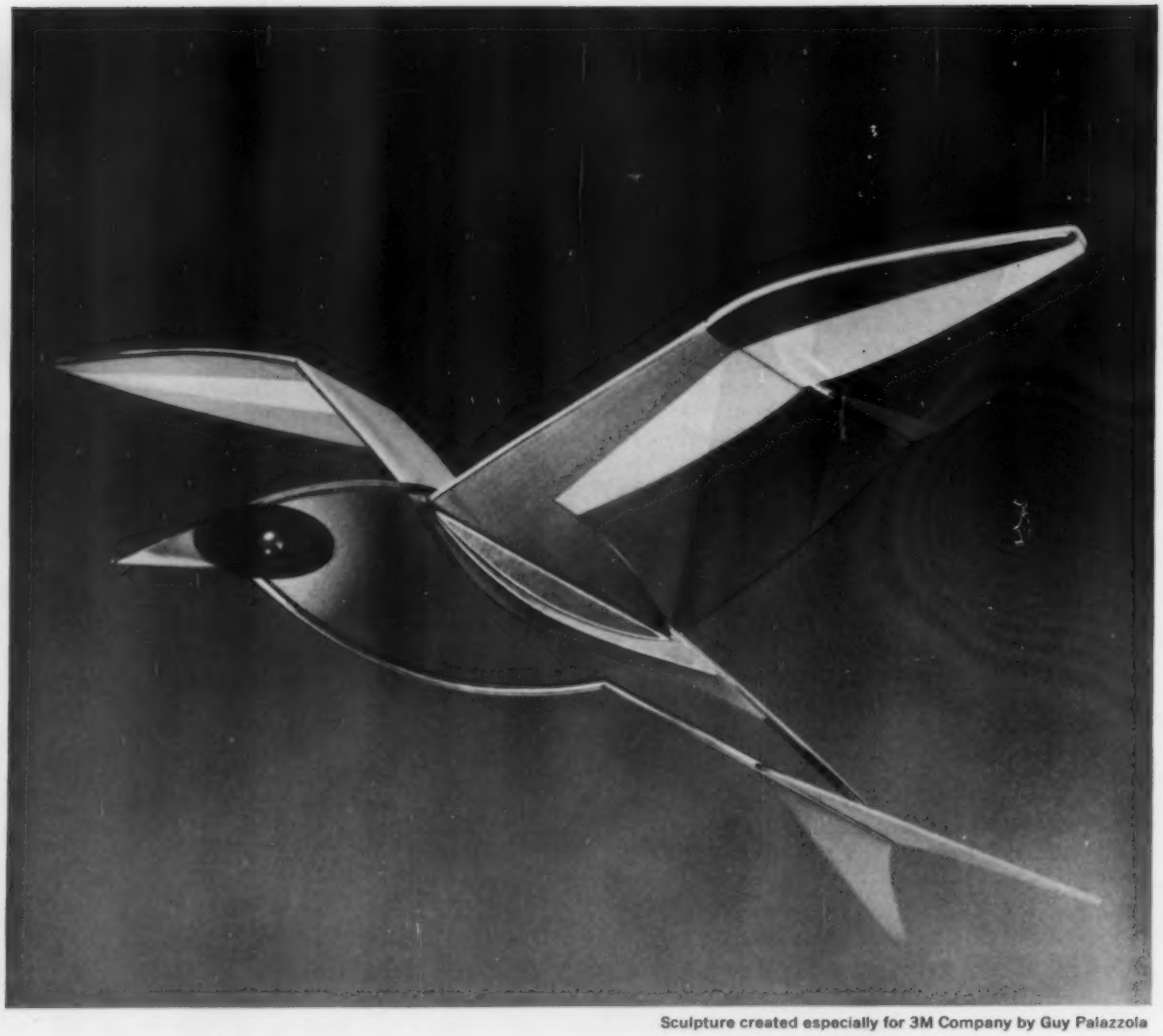
▸ Committee A-5 on Corrosion of Iron and Steel has approved an atmospheric corrosion research program on 65 types of wire coated with zinc or aluminum.

▸ A method for determining the spalling resistance of porcelain enameled aluminum has been approved by Committee C-22 on Porcelain Enamel. There have been no authenticated cases where specimens passed the test and then failed in service.

▸ Standard methods are now being developed by Committee E-1 on Methods of Testing for the comparison calibration of thermocouples and for testing element materials by comparison to secondary standards. The Committee is preparing two manuscripts to make the most up-to-date thermocouple information available to industry.

Correction

The sponsor of the recent competition for nonferrous metal powder parts was New Jersey Zinc Co., not the Metal Powder Industries Federation as announced in M/DE, Jan '61, p 23. Our apologies for any confusion our error may have caused.



Sculpture created especially for 3M Company by Guy Palazzola

FEATHER-LIGHT...

3M Adhesives help take pounds off today's metalworking products

Reducing dead weight can give a product extra sales advantages . . . make it easier to handle and assemble . . . lower shipping and production costs. The answer: Fabricate with 3M Industrial Adhesives and save weight without sacrificing strength.

In fact, 3M Adhesives often substantially increase the strength of an assembly by distributing stresses evenly over a wide area, making lightweight, high-strength designs possible. And without mechanical fasteners that lower the integrity of the material and cause stress points that tear, fabricators can substitute lighter gauge materials.

For example, 3M Adhesive EC-1357—only one of a complete line of strong, general purpose industrial adhesives—finds wide application in products requiring strength and light weight. It is used in the bonding of metal frames to veneered plywood . . . in honeycomb construction for table tops . . . in sandwich-type wall panels, where it bonds porcelain enameled steel to an expanded glass core.

Backed by a quarter century of research, 3M Technical Service is solving fabrication problems for leading manufacturers in various industries. For an accurate appraisal of how an adhesive can add strength, light weight, production economy, and greater design freedom to your process or product, look first to 3M. Write AC&S Division, 3M Company, Department SBHH-41, St. Paul 6, Minnesota.

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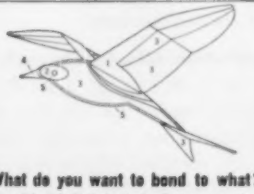

What do you want to bond to what?

The Bird is fabricated of these materials and bonded with a variety of 3M Adhesives:

1. Stainless Steel 2. Wood 3. Plastic 4. Glass 5. Brass.

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Coming Meetings

OIL & GAS POWER CONFERENCE & EXHIBIT, American Society of Mechanical Engineers. New Orleans. Apr 9-13.

AGGLOMERATION SYMPOSIUM, American Institute of Mining, Metallurgical and Petroleum Engineers. Philadelphia. Apr 12-14.

AMERICAN WELDING SOCIETY, 42nd annual convention and exposition. New York City. Apr 17-21.

SOCIETY OF THE PLASTICS INDUSTRY, Western Section, 18th Annual Conference. Coronado, Calif. Apr 20-21.

METALS ENGINEERING CONFERENCE, American Society of Mechanical Engineers. Pittsburgh. Apr 23-26.

POWDER METALLURGY SHOW, Metal Powder Industries Federation. Cleveland. Apr 24-26.

HIGH TEMPERATURE MATERIALS CONFERENCE, Metallurgical Society of American Institute of Mining, Metallurgical & Petroleum Engineers. Cleveland. Apr 26-27.

AMERICAN ZINC INSTITUTE, INC., Galvanizers Committee. Chicago. May 1-2.

LEAD INDUSTRIES ASSN., 33rd Annual Meeting. Chicago. May 2-3.

LUBRICATION SYMPOSIUM, American Society of Mechanical Engineers. Miami Beach. May 8-9.

CASTINGS CONGRESS & EXPOSITION, American Foundrymen's Society. San Francisco. May 8-12.

PRODUCTION ENGINEERING CONFERENCE, American Society of Mechanical Engineers. Toronto. May 10-12.

AMERICAN SOCIETY OF TOOL AND MANUFACTURING ENGINEERS CONVENTION, Exposition of Creative Manufacturing Equipment. New York. May 22-26.

DESIGN ENGINEERING CONFERENCE, Machine Design Div., American Society of Mechanical Engineers. Detroit. May 22-25.

DESIGN ENGINEERING SHOW, sponsored by Clapp & Poliak, Inc. Cobo Hall, Detroit. May 22-25.

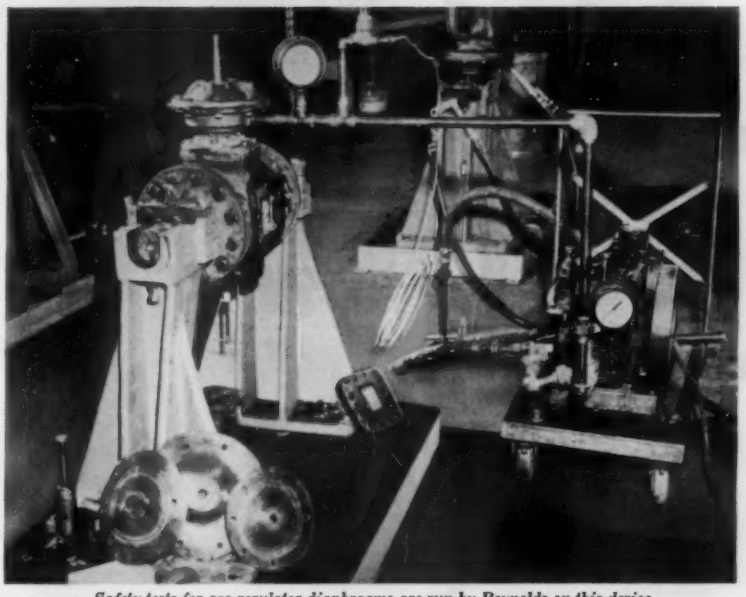
9TH NATIONAL PLASTICS EXPOSITION AND CONFERENCE, Society of Plastics Industry. New York City. June 5-9.

MALLEABLE FOUNDERS SOCIETY, Annual Meeting. Colorado Springs, Colo. June 8-9.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Annual Meeting. Los Angeles. June 11-15.

AMERICAN SOCIETY FOR TESTING MATERIALS, Annual Meeting. Atlantic City. June 25-30.

DIAPHRAGM OF REEVECOTE WITHSTANDS 23,520 LB. THRUST IN SAFETY TEST



Safety tests for gas regulator diaphragms are run by Reynolds on this device fed by a hydraulic pump. Here, on an effective area of 24 sq. in., a Reevecote synthetic diaphragm safely absorbed a total thrust of 23,520 lbs.

The Reynolds Gas Regulator Co., of Anderson, Ind., takes unusual safety precautions to check the tensile strength of diaphragms in their gas regulators.

Some of their diaphragms must absorb sudden surges in pressure—up to 1000 psi. That's why Reynolds runs special safety tests on the diaphragms.

The results of these tests prove the outstanding superiority of diaphragms made of Reevecote.

In a recent test at Reynolds, Reevecote 7270, 0.093" gauge a Buna-N coated nylon, successfully withstood 980 psi on an effective diameter of 24 sq. in.—or a total thrust of 23,520 pounds.

Reevecote diaphragms are flexible and sensitive, yet tough enough to stand up safely under severe extremes of pressure.

If your design calls for the use of diaphragms, or coated fabrics—choose from the most complete source of coated fabrics for industry—REEVECOTE.

REEVES VULCAN

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1071 Avenue of the Americas · New York 18, New York

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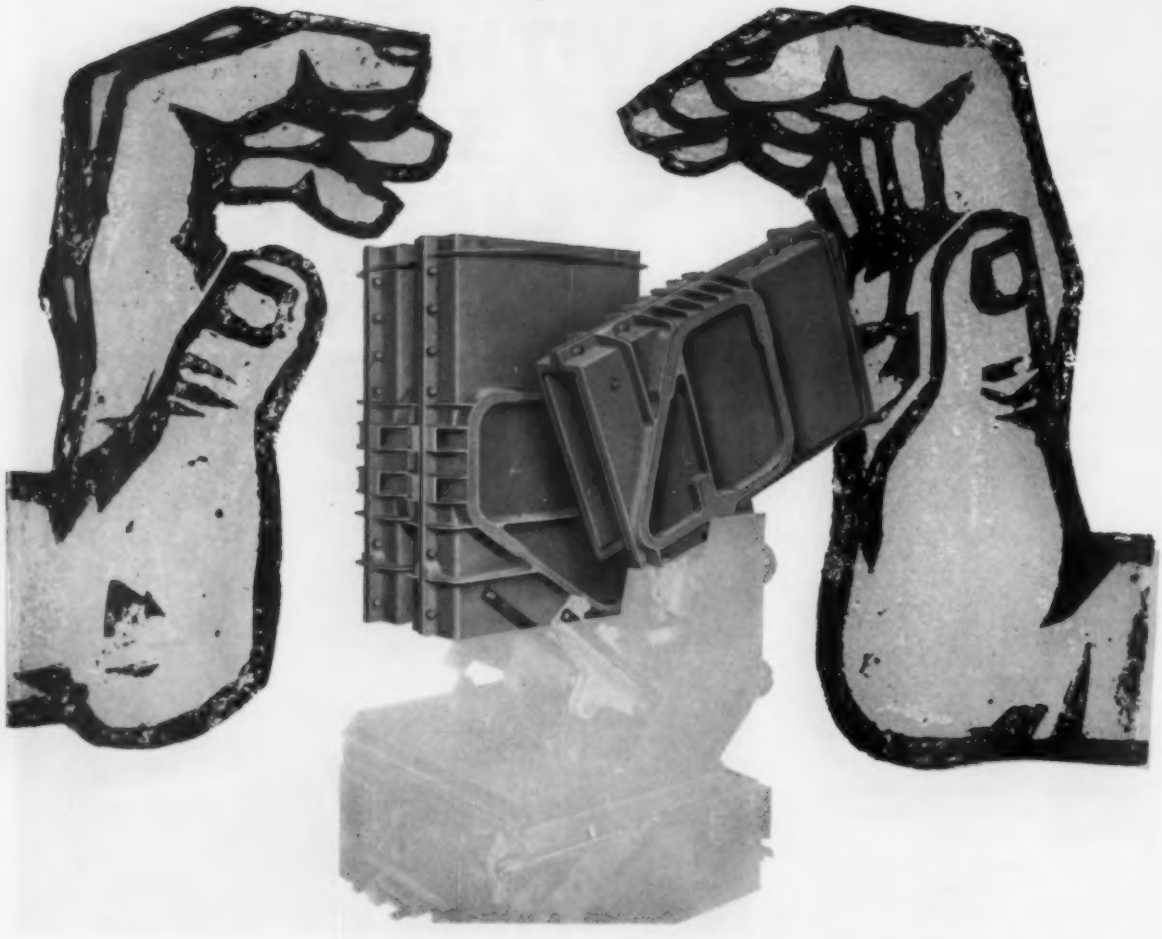

How to squeeze compact switchgear into still less space!

Throughout the electrical industry, they're talking about St. Regis® Panelyte's revolutionary new arc chute for I-T-E's latest switchgear. For, among other advantages, this chute helps make the switchgear approximately one-third smaller than the next most compact unit made.

Each chute is molded at 2,000 psi using a non-tracking, flame-retardant polyester-glass fiber molding compound. Molds are 24″ x 15″ x 2¼″ and must meet a minimum dielectric strength test of 250 volts/mil.

Special test molds—A *joint* Panelyte I-T-E development program was underway long before the first drawing. Panelyte engineers made special test molds to determine the optimum wall configuration for housing the chute's blowout coils. Then Panelyte engineers worked hand-in-hand with I-T-E to cut both overall chute size and unit cost.

Extensive Panelyte manufacturing facilities—When the switchgear's design was frozen, Panelyte's manufacturing group took over. Using special presses, quality production was both fast and economical. Each molding was proof-tested to assure highest quality.

Why don't you take advantage of Panelyte's Customer-Supplier Development Program . . . and of Panelyte's 22 years' experience in high-pressure molding? For complete details on *all* the advantages Panelyte offers you, write today to Dept. MDE-461, Industrial Panelyte Division, St. Regis Paper Company, No. Enterprise Ave., Trenton, N. J.

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Panelyte also produces laminated plastic sheets, rods, tubes and copper-clad stock, as well as special laminates and fabricated parts.

For more information, turn to Reader Service card, circle No. 389

Help needed on . . . polyvinyl toluene

To the Editor:

We need some information on polyvinyl toluene. Could you refer us to a company that manufactures this material? Also, what are its physical and electrical properties, including dielectric constants and dissipation factors?

A. B. CARVER
Project Supervisor
Physics Laboratory
Johns Hopkins University
Silver Spring, Md.

We have been unable to find any reference to such a material.

. . . computing 'k' for small samples

To the Editor:

Your article, "How to Use Probability Paper to Solve Materials Problems" (M/DE, Nov '60, pp 138-142), fell upon most receptive ears. I have employed your methods and will continue wherever applicable. However, I have a problem. You limit your table listing "k" values for sample size and probability levels to a minimum sample of ten units. Where could I find values for "k" below this figure? Also, by what formula was "k" computed?

L. B. ALLEN
Computation Services Dept.
Royal McBee Corp.
West Hartford 10, Conn.

Values of "k" are derived from Fischer's table of "t" values which can be found in almost any reference book dealing with quality control. The particular reference used was Statistical Methods in Quality Control, *D. J. Crowden, Prentice-Hall, 1957. According to Crowden, "t" is defined as "the ratio of a normally distributed deviate with mean zero to an estimate of its standard error based on v degrees of freedom." Mathematically, this is stated as:*

$$t = (\bar{X} - \mu_0)/\sigma_{\bar{x}}$$

However, we are a little dubious about the value of probability plots when sample size drops below ten.

. . . methods of obtaining high vacua

To the Editor:

I am doing research on "methods of obtaining high vacua" and wonder if you might be able to assist me. Do you have on hand any papers or information relevant to the subject, or could you refer me to the proper sources?

MELVIN ANG
Roxbury, Mass.

Since we are primarily an engineering materials magazine, we do not get involved in "methods of obtaining high vacua." However, there was a British

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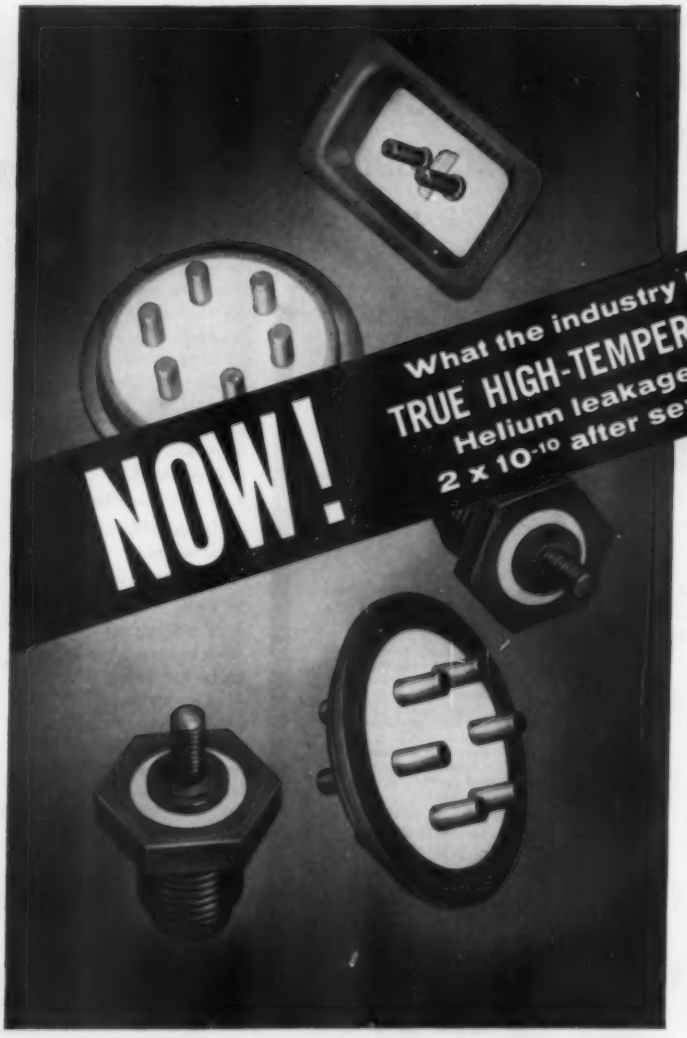
BIG NEWS in high-temperature precision-molded insulation

SUPRAMICA® 620 "BB" ceramoplastic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TRUE HIGH-TEMPERATURE HERMETIC SEALS
Helium leakage rate cc/sec. less than
2 x 10-10 after severe environmental tests.

Need a precision-molded insulation material with total dimensional stability under the most adverse thermal cycling, operating to 1200°F. . . . or a material with previously unattainable combination of properties? Check these facts about new SUPRAMICA 620 "BB" ceramoplastic:

- Maximum temperature endurance of material 1200°F. (unstressed). Heat distortion temperature of material 1100°F. (ASTM D648-264 PSI)
- SUPRAMICA 620 "BB" ceramoplastic can be precision molded to most intricate geometries with gauge-like tolerances.
- SUPRAMICA 620 "BB" ceramoplastic will not carbonize.
- Absolute hermetic seals achieved directly during the molding cycle. Components meet a helium leakage rate of less than 2 x 10^{-10} cc/sec., after the following environmental tests:
  1. Samples heat shocked a total of 20 cycles from boiling water for 30 minutes directly to ice water for 10 minutes.
  2. Samples heat shocked a total of 5 cycles, from 350°C. for 1 hour directly to room temperature for 10 minutes, to -75°C. for 1 hour, to room temperature for 10 minutes.
  3. Samples heated to 500°C. for 4 hours and directly to room temperature.
- Thermal expansion factor matches many metals and alloys.
- New SUPRAMICA 620 "BB" ceramoplastic features a dielectric strength of 270 volts/mil, 1/8" thickness per ASTM D-149.

WRITE for Information and Engineering Data Sheets on **SUPRAMICA 620 "BB"** and other **MYCALEX®** glass-bonded mica or **SUPRAMICA** ceramoplastic insulations.

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magazine published some time ago under the title of Vacua; *a good technical library could no doubt locate it.*

. . . Composite panels for insulation

To the Editor:

Please advise if articles in M/DE or elsewhere summarize latest in composite panels for equipment insulation at moderate temperatures where metal, plastic or other sandwich construction gives adaptable, rugged, light sections at reasonable costs requiring no further finishing.

R. A. STONE
Design and Development
Jabez Burns and Sons, Inc.
New York, N. Y.

We have published no articles specifically on panels for equipment insulation. However, we did publish an article summarizing thermal insulation materials (M/DE, Mar '58). Also, our annual reference issue, The Materials Selector, has a section on composite materials which might be of some help.

Rolled-in scale is really oxidation

To the Editor:

Your article on "Heat Treatable Copper Alloys" (M/DE, Jan '61, p 84) should be of interest to designers. We are glad to see this article published because it presents valuable information on an important group of engineering alloys. However, we believe the statement regarding "rolled-in subsurface scale" on chromium copper should be corrected.

The scale condition referred to is known in the brass industry by such names as "sub-scale" and "internal oxidation." It is not due to "rolling-in" of scale as stated, but rather it results from the internal oxidation of chromium during solution annealing. This layer of internally oxidized material is composed of chromium oxide particles in copper; below this surface layer is the normal chromium copper. Since the "sub-scale" layer is due to oxygen penetration, it can be, and is, prevented commercially by using a slightly reducing atmosphere during the solution anneal.

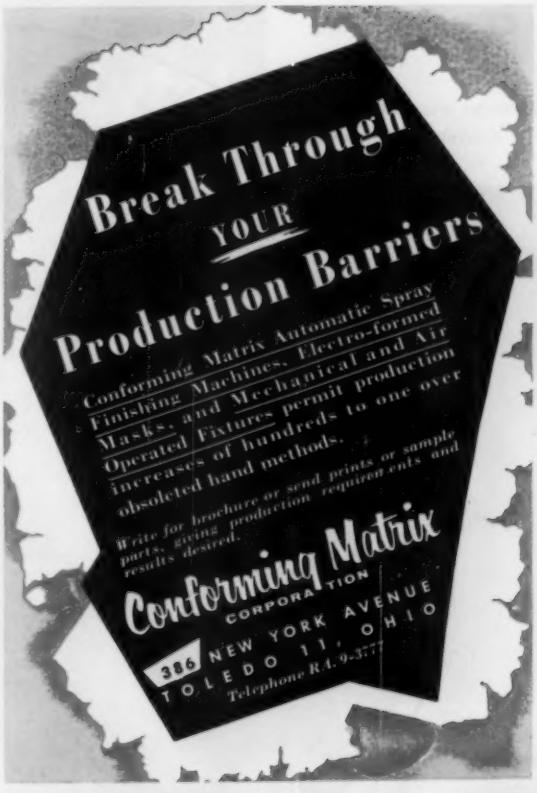
J. P. LYNCH, JR.
Metallurgical Dept.
Ansonia Div.
Anaconda American Brass Co.
Ansonia, Conn.

ABC's of ABS availability

To the Editor:

In your special report on "Chemical Process Equipment: What Materials Are Next?" (M/DE, Feb '61, p 111), you indicated that pipe fittings made of ABS materials are not considered to be generally available in quantity or size. This simply is not the case; actually, there are more sizes and available sources for ABS fittings than there are for any other plastics piping materials.

J. F. POSTELL
J. F. Postell Co.
Cranford, N. J.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TubeXperience in action

Wind Velocities to Mach 7 Prove Needle-Size Superior Stainless Tubing

Manometer lines of Superior Type 304 stainless tubing, drawn to needle size, withstand the vibration caused by air speeds beyond Mach 7 and internal pressures as high as 5000 psi in FluiDyne wind-tunnel tests of missile component models. And they have been in some assemblies for 3½ years without cracking, pinholing or buckling.

FluiDyne Engineering Corp., one of the major designers of such test facilities, attributes the long life of this Superior tubing to both its high modulus of elasticity and its resistance to the corrosive effects of mercury and soldering-flux acid.

Ductility is a big advantage, too. This permits the Superior tubing to be easily hand-bent into complex shapes for application in wind tunnels and readout equipment.

Filling stainless steel tubing orders that call for tiny needle tubing in gages from 6 to 33 or tubing with OD's as large as 1.125 in. calls for the resources Superior has to offer. Why not investigate us as a source of small-diameter stainless tubing. Catalog 21 describes the types and analyses available. Also gives tips on its selection and application. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

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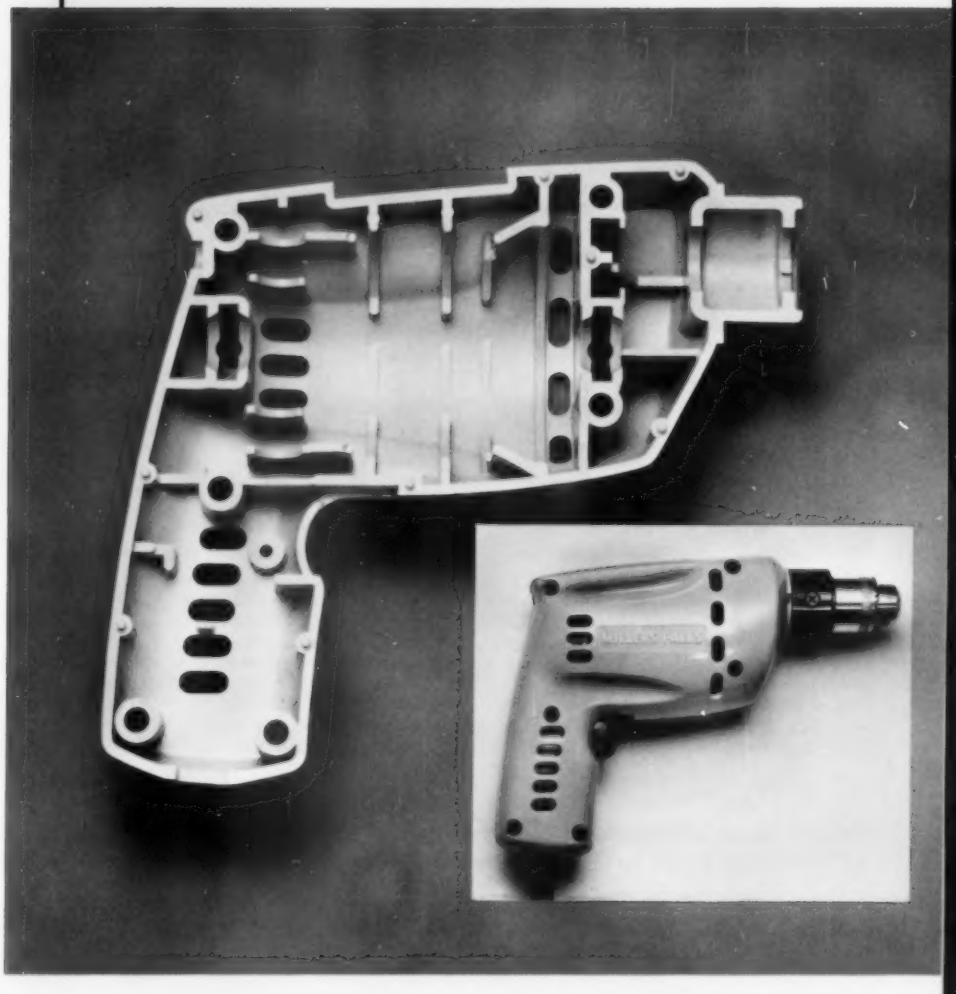
nylon resins

one of Du Pont's versatile engineering materials



New drill housing of ZYTEL® NYLON RESINS insulates ...eliminates costly machining operations

A basic design advance in power tools, this ¼" drill is made with a nonconductive housing of Du Pont ZYTEL nylon resin. Double-insulated, it protects the user against shock hazard. Other design advantages include a weight saving: the housing of ZYTEL is 20% lighter than a comparable housing of aluminum. It is self-extinguishing. It stays comfortable to the touch in hot and cold weather and after prolonged use. It is rugged, durable and impact-resistant.

In addition, the use of ZYTEL affords substantial production advantages. The two halves of the drill housing, though complex in design, are quickly and easily molded. The excellent dimensional stability of ZYTEL assures a perfect match of each half for screw inserts, assembly and flange matings. And the housing requires no machining operations whatever.

Molded by Nylon Products Corp., affiliated with F. J. Kirk Molding Co., Clinton, Massachusetts, for Millers Falls Company, Greenfield, Mass.

On the following page you will find additional examples of practical design improvements made possible by the combination of properties that ZYTEL nylon resins offer.

DU PONT

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. . . THROUGH CHEMISTRY

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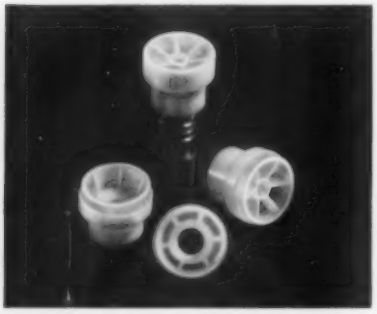
Du Pont Zytel®

nylon resins

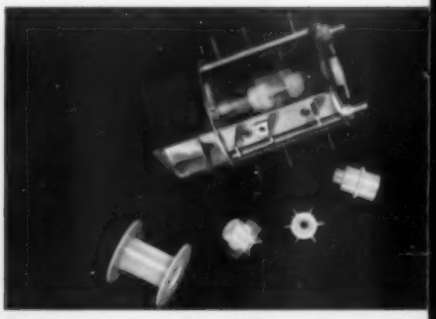
one of Du Pont's versatile engineering materials

Parts of ZYTEL® NYLON RESINS perform reliably under attack by heat, impact and chemicals

This oil slinger swirls oil onto vital engine parts. It must be tough, resistant to impact, abrasion and attack by oil at high temperatures. ZYTEL provides all these resistant properties and permits economical injection molding of the part. (Molded by Sinko Mfg. & Tool, Chicago, Ill., and Danielson Mfg. Co., Danielson, Conn., for Briggs & Stratton, Milwaukee, Wis.)



These faucet-handle inserts are designed for interference-fit assembly and to act as an insulator against heat. These rugged parts of ZYTEL will withstand 116 inch-pounds torque at the stem between 20° and 160°F. They are expected to give at least 20 years of efficient service. (Molded for American Radiator & Standard Sanitary Corp., New York, New York.)



This compact switch relay uses parts molded of ZYTEL to withstand rugged treatment and yet operate quickly, smoothly and positively. Necessary in this application are good heat resistance, good electrical properties and high strength in thin sections. ZYTEL fills the bill. (Molded by Ritepoint Pen & Pencil Co., for Warco Industries, both of St. Louis, Missouri.)

An important factor in the design versatility of ZYTEL nylon resins is their ability to be molded to accurate tolerances without costly machining. Equally important is the wide variety of ZYTEL nylon resins available to meet special problems. All ZYTEL compositions have the basic properties of low friction, impact and abrasion resistance, high strength and resistance to chemicals.

Du Pont ZYTEL may help you, too, to improve the performance or the economics of a part or product. The coupon below will bring you information relating to your own problem or field of interest.

POLYCHEMICALS DEPARTMENT

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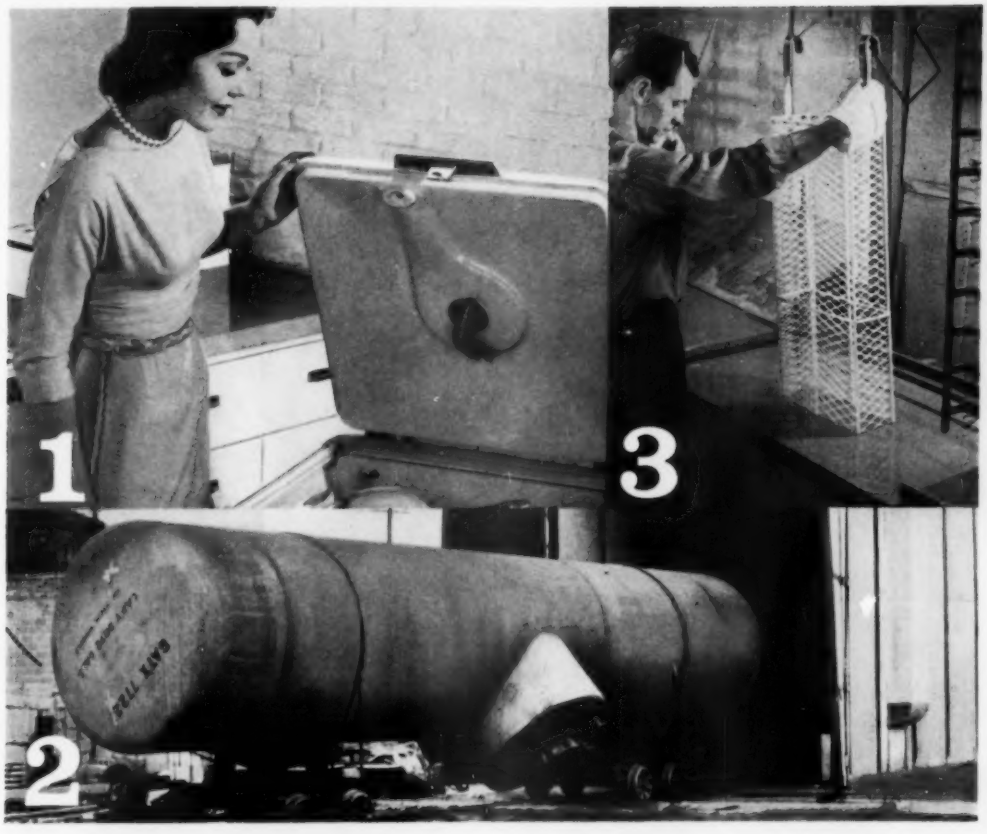

Size and severe service prove no deterrents to plastisol usage

In the family of finishing materials available today, plastisols provide some of the most versatile of coatings for severe end-use conditions. They combine the well known chemical inertness of vinyl resins with heavy film buildup, resiliency, and truly remarkable wearing and abrasion resisting qualities.

Such physical advantages are applicable not only on the production line but also in many unusual protective maintenance jobs. As long as the metal object can be heated and held to the required curing temperature of 350°F for 20 minutes, plastisols can replace and improve on many other types of coating materials; or permit use of ordinary metals where costly alloys or other materials are generally needed. Examples:

1. DISHWASHER TUB LINING. Consider the service conditions: scalding water, mixed with strong cleaners, impinging with high velocity on tub. Add to this the need to resist food stains, to avoid cuts and impact damage from dropped or broken objects. Despite all service hazards, the lining must be able to last the life of the machine. A Unichrome Plastisol Compound satisfies these rigorous conditions, and more, for a number of famous dishwasher lines.

2. INERT TANK CAR LINING. Sprayable Unichrome Super 5300 Plastisol solved this problem, too, permitting use of a steel car instead of an expensive alloy one. Three sprayed coats gave a lining 120 mils thick. There were no seams at bends and joints to cause trouble; nor any thin spots to be penetrated. In effect, it was like applying a sheet lining through a spray gun. Baking, of course, was a gigantic job, requiring an oven 60 feet long. But result is a car capable of countless trips without risk of contaminating edible or chemically active contents.

3. PROCESSING RACKS. No stronger testimonial of durability exists for Unichrome Plastisol Coating than its use for electrically insulating a plating rack. It's immersed in hot, acidic or alkaline plating baths; again in boiling cleaners, even goes through vapor degreasing cycles. The coating withstands physical abuse, impact. Yet, it goes on and on, for thousands of plating cycles. Some plants report up to six years of service with minimum maintenance.

Send for data, or specific recommendations on a formulation to fit your requirements.

M&T coatings and finishes

METAL & THERMIT CORPORATION GENERAL OFFICES: RAHWAY, NEW JERSEY IN CANADA: M&T PRODUCTS OF CANADA LTD., REXDALE, ONT.

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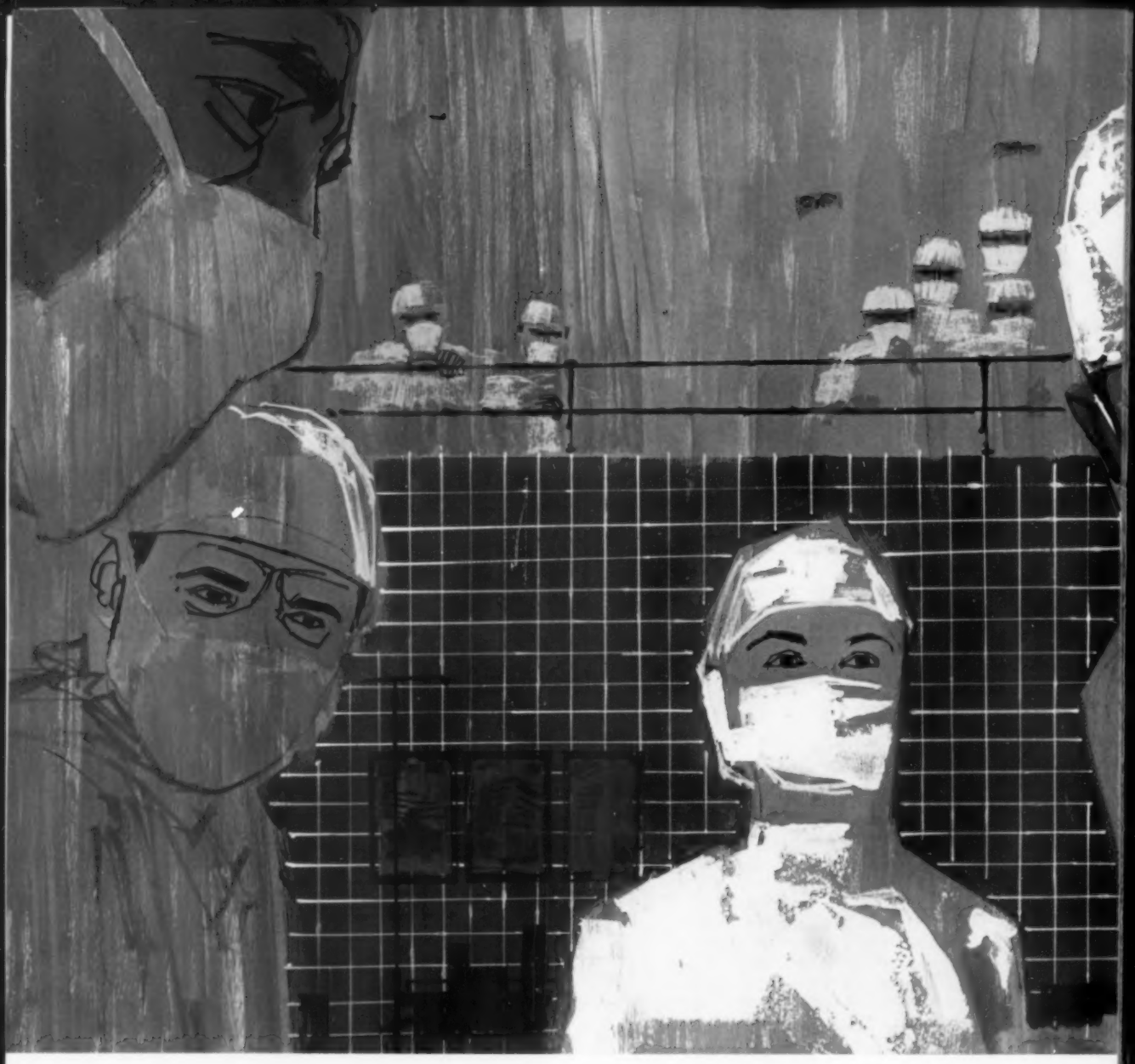


NS SPECIAL WIRE TRANSMITS

Doctors are saving more lives today in heart surgery cases through the transmission of carefully timed electrical pulses into the heart. Many patients suffering from lost heartbeat due to surgery or other causes have been restored to active life through such heart stimulation.

A LEADING MEDICAL INSTRUMENT COMPANY developed a pocket-size electronic package to generate the electrical impulse, which is transmitted to the heart through the jugular vein by a tiny stainless steel braided wire.

In their search for the right conductor to carry the electric pulses to the heart, researchers came to National-Standard for help in developing a wire flexible enough to follow the intricate path of the circulatory system, while, at the same time, soft enough to avoid damaging the blood vessels or the heart itself. In addition, the wire had to be very thin, strong enough to withstand the constant flexing of the heart, and with just the proper electrical characteristics.

NATIONAL-STANDARD ENGINEERS developed a braid of 16 wires, each .0036″ diameter, or about the thickness of human hair. Using type 302 stainless

SPARK OF LIFE

steel wire, NS engineers produced a braided wire with high tensile strength, good resistance to fracture, good conductivity and flexibility just right for the delicate application.

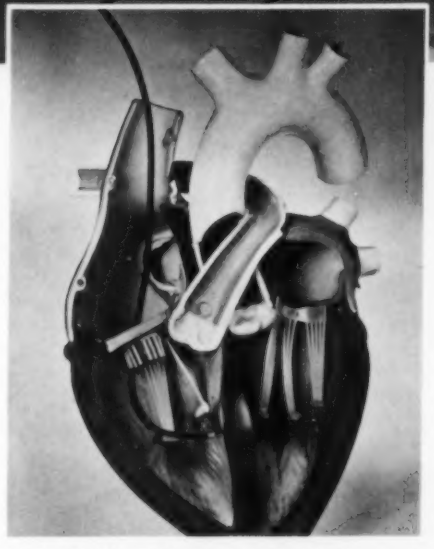
EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring high-quality wire, to meet special or unique applications, is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.

NS NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire and Metal Products

NATIONAL-STANDARD COMPANY

Niles, Michigan



NS SPECIAL WIRE transmits spark of life from transistorized, battery-powered package, through jugular vein, to the heart. Carefully timed electrical pulses train tired hearts to beat normally again.

Technical-ities

By Fred E. Graves

Fastening of "blind hole" joints

Holes which don't go all the way through a solid member must be tapped, of course. In shallow, small holes, in non-critical fastening, and in soft materials thread cutting screws work well and save time.

But fastening large flanges, pressure plates, heads and the like to costly castings needs more precise production. These holes are ¼" diameter and larger, affect design strength.

THREAD EFFECTS

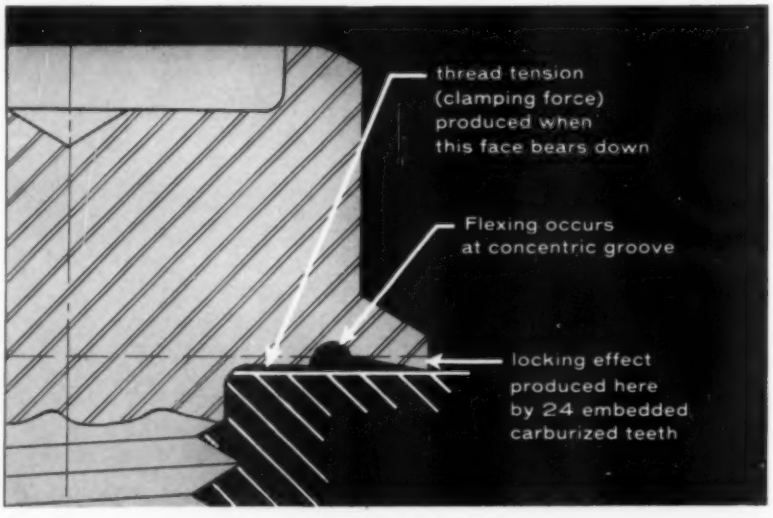
Such holes are coarse threaded. The coarse threads develop more thread strength than do fine threads, also take fewer turns in assembly. Studs go into the holes with an interference thread fit; hex screws with a simpler clearance fit.

Desirably, studs should all be driven to same depth and bottomed. Because of normal manufacturing differences, various mismatched high and low tolerances will cause studs to project unevenly. Assemblers often have to juggle. No such problem exists with hex screws. You just tighten to specified preload. And there's no double driving operation, as with stud plus nut.

STRENGTH OF BLIND JOINTS

Tapped holes behave like nuts. Their threads adjust elastically and plastically to distribute stress and develop high thread tension. Is this harmful in repeated disassemblies? Not at all. Hex screws have been installed 50 times in cast iron test blocks, then tightened to failure without damage to tapped holes.

Clamps like a hex screw Grips like an anchor


thread tension (clamping force) produced when this face bears down
Flexing occurs at concentric groove
locking effect produced here by 24 embedded carburized teeth

Tensilock® screws offer you the ideal combination of high clamping force and high locking power.

While a standard high strength hex screw can be tightened to a higher thread tension, its off-torque is less than its on-torque.

ANCHORED IN PLACE

The *"Tensilock"* screw features ratchet action teeth formed at an angle which will cut driving effort to permit you to utilize more of the full strength of screw. At equal driving torque, it not only develops 90% of the strength of a high strength hex screw but also takes *25% more torque to loosen than to tighten.*

Because of the flange's concentric groove, it flexes, allows the screw to bear down solidly on its seat and develop a high level of thread tension. At the same time the teeth embed themselves, are aided in maintaining their grip by pressure of the spring-action flange.

MAKES GOOD FRICTION-TYPE JOINT

Clamping force from Tensilock fasteners is sufficient to prevent slippage of fastened members where holes are oversize or eccentric. Grip of the teeth keeps fasteners tight under conditions of vibration or cyclic temperature changes. RB&W *"Tensilock"* Nuts also available. Write for Bulletin TL-2. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

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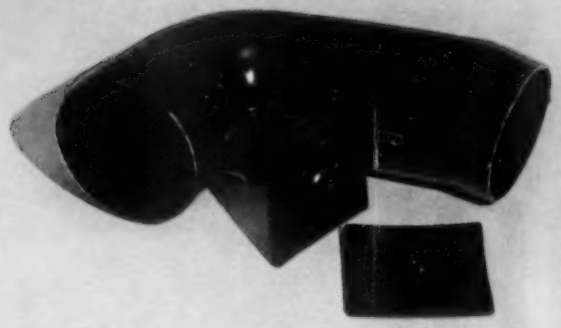


Spring Silencers and Heater Duct—MARLEX silencers are durable, self-lubricating, and less costly. Duct is flexible, rot-proof, withstands tears and punctures.

Seat Side Shields—Cost less than painted steel . . . dent and scuff resistant, lighter, easily cleaned, and with "molded in" texture and color.

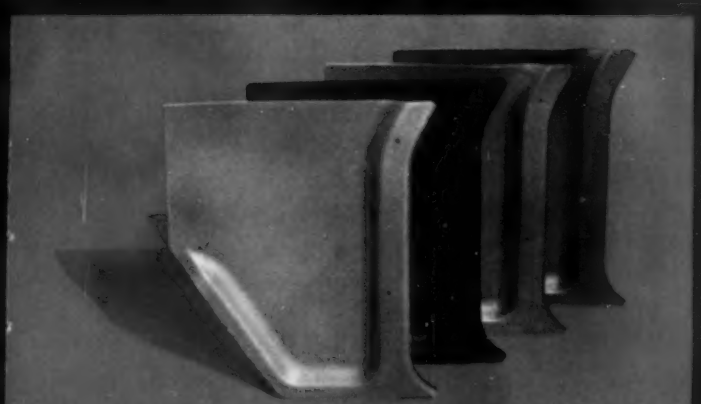
Windshield Washer Jar—Container made of MARLEX won't shatter or burst . . . is unaffected by freezing or under-the-hood temperatures.

The MARLEX* look on 1961 cars

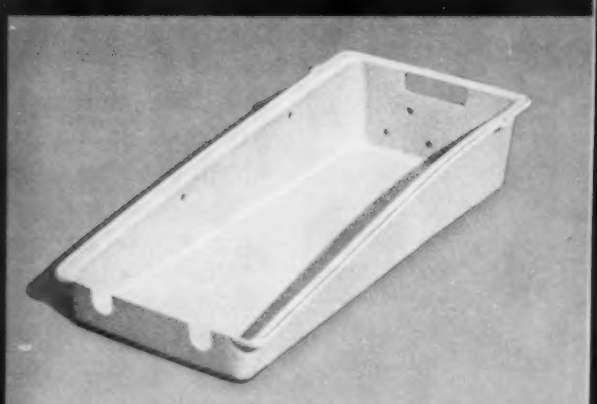
Shown here is a selection of current applications for MARLEX variously used by American Motors, Chrysler Corp., Ford, and GM. They offer new proof of the improved performance (at comparable or lower costs) provided by this versatile, high density plastic.

MARLEX items (like the original equipment applications shown here) are unaffected by extremes of temperature (—180°F to 250°F) and resistant to acids, alkalies, oil and grease. They are lightweight, tough, durable, non-allergenic, corrosion- and rot-proof . . . can be machined, welded, bolted, and printed upon. There are production advantages, too. Superior finished items can be quickly and economically produced from MARLEX high density resins by injection molding, extrusion, blow molding or thermoforming.

Technical and design data on MARLEX high density polyethylenes and ethylene copolymers, and their many uses, is available to you.



Side Cowl Panels—Colorful and textured MARLEX panels improve styling . . . will not scuff, dent, or tear . . . are color fast and easily cleaned.



Glove Compartment—Economical "quality upgrading" with MARLEX . . . new box is rugged, functional, and longer lasting.

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For more information, see your plastic fabricator . . . or contact us.

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PHILLIPS 66 MARLEX

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New materials in this issue:

	Page	Circle Key No.
METALS		
Grain size control in castings	9	601
New tool steel	17	605
Fiber metal seals	17	606
Manganese bronze	164	615
Stainless steel resists combustion products	172	621
PLASTICS & RUBBER		
New thermoplastic is strong, tough	12	603
New plastics	19	607
Foam plastics	176	623 to 625
Synthetic rubber has good color stability	180	626
Polystyrene has good impact strength at —20 F.	182	627
OTHER NONMETALLICS		
Fiber-resin ceramics	14	604
Contoured woodchip parts	158	610
Synthetic felts are strong, heat resistant	166	616
Dry film lubricants are noncorrosive	166	617
FINISHES, COATINGS		
New pipe lining process	10	602
Vinyl coating protects with single layer	170	619
Epoxy coating cures to tile-like finish	185	641
Strippable vinyl coating	185	642
FASTENING		
Three new adhesives	160	611 to 613
Silver brazing flux	185	646
Epoxy adhesive	185	646
Adhesive for plastics	185	648

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2	27	52	77	102	127	152	177	202	227	252	277	302	327	352	377	402	427	452	477	502	527	552	577	602	627	652	677
3	28	53	78	103	128	153	178	203	228	253	278	303	328	353	378	403	428	453	478	503	528	553	578	603	628	653	678
4	29	54	79	104	129	154	179	204	229	254	279	304	329	354	379	404	429	454	479	504	529	554	579	604	629	654	679
5	30	55	80	105	130	155	180	205	230	255	280	305	330	355	380	405	430	455	480	505	530	555	580	605	630	655	680
6	31	56	81	106	131	156	181	206	231	256	281	306	331	356	381	406	431	456	481	506	531	556	581	606	631	656	681
7	32	57	82	107	132	157	182	207	232	257	282	307	332	357	382	407	432	457	482	507	532	557	582	607	632	657	682
8	33	58	83	108	133	158	183	208	233	258	283	308	333	358	383	408	433	458	483	508	533	558	583	608	633	658	683
9	34	59	84	109	134	159	184	209	234	259	284	309	334	359	384	409	434	459	484	509	534	559	584	609	634	659	684
10	35	60	85	110	135	160	185	210	235	260	285	310	335	360	385	410	435	460	485	510	535	560	585	610	635	660	685
11	36	61	86	111	136	161	186	211	236	261	286	311	336	361	386	411	436	461	486	511	536	561	586	611	636	661	686
12	37	62	87	112	137	162	187	212	237	262	287	312	337	362	387	412	437	462	487	512	537	562	587	612	637	662	687
13	38	63	88	113	138	163	188	213	238	263	288	313	338	363	388	413	438	463	488	513	538	563	588	613	638	663	688
14	39	64	89	114	139	164	189	214	239	264	289	314	339	364	389	414	439	464	489	514	539	564	589	614	639	664	689
15	40	65	90	115	140	165	190	215	240	265	290	315	340	365	390	415	440	465	490	515	540	565	590	615	640	665	690
16	41	66	91	116	141	166	191	216	241	266	291	316	341	366	391	416	441	466	491	516	541	566	591	616	641	666	691
17	42	67	92	117	142	167	192	217	242	267	292	317	342	367	392	417	442	467	492	517	542	567	592	617	642	667	692
18	43	68	93	118	143	168	193	218	243	268	293	318	343	368	393	418	443	468	493	518	543	568	593	618	643	668	693
19	44	69	94	119	144	169	194	219	244	269	294	319	344	369	394	419	444	469	494	519	544	569	594	619	644	669	694
20	45	70	95	120	145	170	195	220	245	270	295	320	345	370	395	420	445	470	495	520	545	570	595	620	645	670	695
21	46	71	96	121	146	171	196	221	246	271	296	321	346	371	396	421	446	471	496	521	546	571	596	621	646	671	696
22	47	72	97	122	147	172	197	222	247	272	297	322	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697
23	48	73	98	123	148	173	198	223	248	273	298	323	348	373	398	423	448	473	498	523	548	573	598	623	648	673	698
24	49	74	99	124	149	174	199	224	249	274	299	324	349	374	399	424	449	474	499	524	549	574	599	624	649	674	699
25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700

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Organic Coatings for Metal Products	676
Guide to Plastics Selection	675
How to Select a Stainless Steel	674
Sheet Formed Plastics Parts	673
Sleeve Bearing Materials	672
Designing Metal Stampings	671
Paper as an Engineering Material	670
Porcelain Enamels Ceramic Coatings	669
Designing with Heat Treated Steels	668
New Developments in Ceramics	667
Thermal Insulation Materials	666
Aluminum Alloy Castings	665
Joining & Fastening Plastics	664

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Books, p 51
Reports, p 54

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Specifying O-Rings. Advanced Products Co., 59 Broadway, North Haven, Conn. Slide rule chart enables specification of metal O-Rings in diameters ranging from ¼ in. to 50 in. Write directly on company letterhead to Advanced Products.

Insulated Wire. Aero Research Instrument Co., Inc., No. 4. Advantages; sizes; uses; and descriptions of sheath materials, insulation and wires; for use up to 3000 F. **177**

Steel Selection Guide. American Metal Climax, Inc., Climax Molybdenum Co. Div., 77 pp, illus. Comprehensive guide presents information on how to combine sound design principles, proper selection of steels, and good heat treatment to achieve best material performance. Specific discussions deal with stress concentrations, design, types of steel, mechanical properties, hardening and hardenability, cold shearing, annealing, machining, heating, quenching, tempering, carburizing, nitriding, cold working, welding, etc. **2**

Inspecting Galvanized Products. American Zinc Institute, 32 pp, illus., No. AZI-40. Manual describes significant factors governing inspection, properties, specification, and purchasing of hot dip zinc coatings. Subjects covered include: thickness and uniformity, coating weight requirements, adherence, embrittlement, warpage and distortion, metallurgical structure of coating, methods of testing, etc. Includes data on product design and a check list of defects, possible causes and recommended action. **3**

Bronze Die Alloy. Ampco Metal, Inc., 4 pp, No. G-55. Advantages, properties, available sizes, typical applications, and other information on a new hard bronze die alloy for drawing, forming and bending stainless and clean mild steels. **4**

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Metal Buyers' Guide. Chase Brass & Copper Co., 16 pp, illus. A directory of products available from this company, including aluminum, brass, bronze, copper, nickel, silver, rhenium, stainless steel, and zirconium. **8**

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Technical Ceramics. Du-Co Ceramics Co., 8 pp, illus., Nos. 59-10, 60-5, 60-6. Physical, mechanical, and electrical properties of steatite, forsterite, alumina, mullite, zirconia, and other technical ceramics. Includes technical data and specifications on insulation tubing for thermocouple wire. **14**

Acetal Resin. E. I. du Pont de Nemours & Co., Polychemicals Dept., 24 pp, illus., No. A-18404. Properties, design considerations, forming techniques, and typical applications of acetal resin. Discusses strength and stiffness, resilience, impact and fatigue resistance, gear properties, friction and bearing properties, abrasion, chemical and heat resistance, dimensional stability, and fabrication and finishing. **15**

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TECHNICAL LITERATURE

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Expansion Inserts. Heli-Coil Corp., Phelps Mfg. Div., 2 pp, illus., No. P-101. Tells how an expansion insert can be used to form permanent brass threads in plastics and other materials. Explains how mold construction can be simplified, open press time reduced, and flash removal eliminated. **166**

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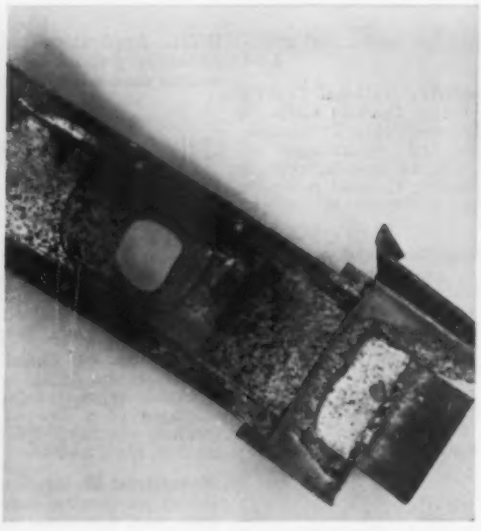

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(cont'd from p 49)

Books

Cermets. *Edited by J. L. Tinklepaugh and W. R. Crandall. Reinhold Publishing Corp., New York. 1960. Cloth, 6 by 9 in., 232 pp. Price $9.50*

Reviewed by Winston Duckworth*

The stated purpose of this book is to review the technology of cermets. Material from 23 contributors is compiled under the following major technical headings: physicochemical aspects of cermets, preparation of oxides and carbides, fabrication techniques, oxide-base cermets, carbide-base cermets, and testing and application of cermets.

The section on physicochemical aspects, by M. Humenik, Jr. and T. W. Whalen, is outstanding. The authors present comprehensive information on surface energy of solids and liquids, and on solid-liquid interfacial energy, in treating the broader subject of wetting. The excellent coverage of these subjects makes the book valuable beyond its intended scope. About one-fifth of the book is taken up by this discussion.

Fabrication techniques

The sections on preparation of oxides and carbides and on fabrication techniques are not particularly exhaustive. Except for a contribution by B. C. Weber on slip casting with clay-free slips, these sections would seem of little interest or value to anyone not intimately concerned with cermets. Weber's authoritative review covers both theoretical and practical aspects.

Preferred methods of processing alumina-chromium cermets are described by T. S. Shevlin. In another contribution, commercially available alumina-chromium cermets are described and some potential applications indicated.

Properties

Properties of titanium carbide-base cermets are discussed primarily in terms of their utility in turbine blades. Attention is given to variations in properties as a function of metal content and type for cermets made by normal powder processing and by infiltration techniques. Properties covered include stress-rupture, impact resistance, fatigue and oxidation resistance.

Other contributions in the book cover diverse subjects and in general are not comprehensive. Subjects include: chromium carbide applications, container materials for melting reactive metals, electronic refractory cermets, cermets in friction materials, metal reinforcement and cladding of cermets and ceramics, an impact test for use with cermets, application of cermets to nuclear devices, and application of cermets to aircraft power plants.

Bibliography

As is common with books written by several authors, the continuity is not what it would have been had the book been written by a single author. Also, the nature and coverage of individual chapters vary. A bibliography listing 544 publications is included; however, the listing is alphabetical by author and the reader cannot learn much about literature on specific subjects. Had the publications been categorized or abstracted in the bibliography, the value of the book would have been enhanced.

Offsetting this complaint, however, is the fact that most of the contributors provide references on the particular subject discussed.

The Extrusion of Metals. *Claude E. Pearson and Redvers N. Parkins. John Wiley & Sons, Inc., New York. 1960. Cloth, 5½ by 8¾ in., 336 pp. Price $7.50*

Provides information on both basic principles and recent advances in metal extrusion. Beginning with an historical survey of the extrusion process, the book goes on to discuss specifically the extrusion of lead and other soft metals, extrusion of cable sheathing, equipment for hot extrusion of hard metals, properties of extruded metals, and extrusion pressures.

Of special interest are chapters on extrudable metals and alloys, flow in metals during extrusion, impact methods of extrusion, and special applications of extrusion.

Fatigue Testing and Analysis of Results. *W. Weibull. Pergamon Press, Inc., New York. 1961. Cloth, 7 by 10 in., 320 pp. Price $15*

This book, published for the Advisory Group for Aeronautical Research and Development, North

(continued on p 54)

* Chief, Ceramic Div., Battelle Memorial Institute.

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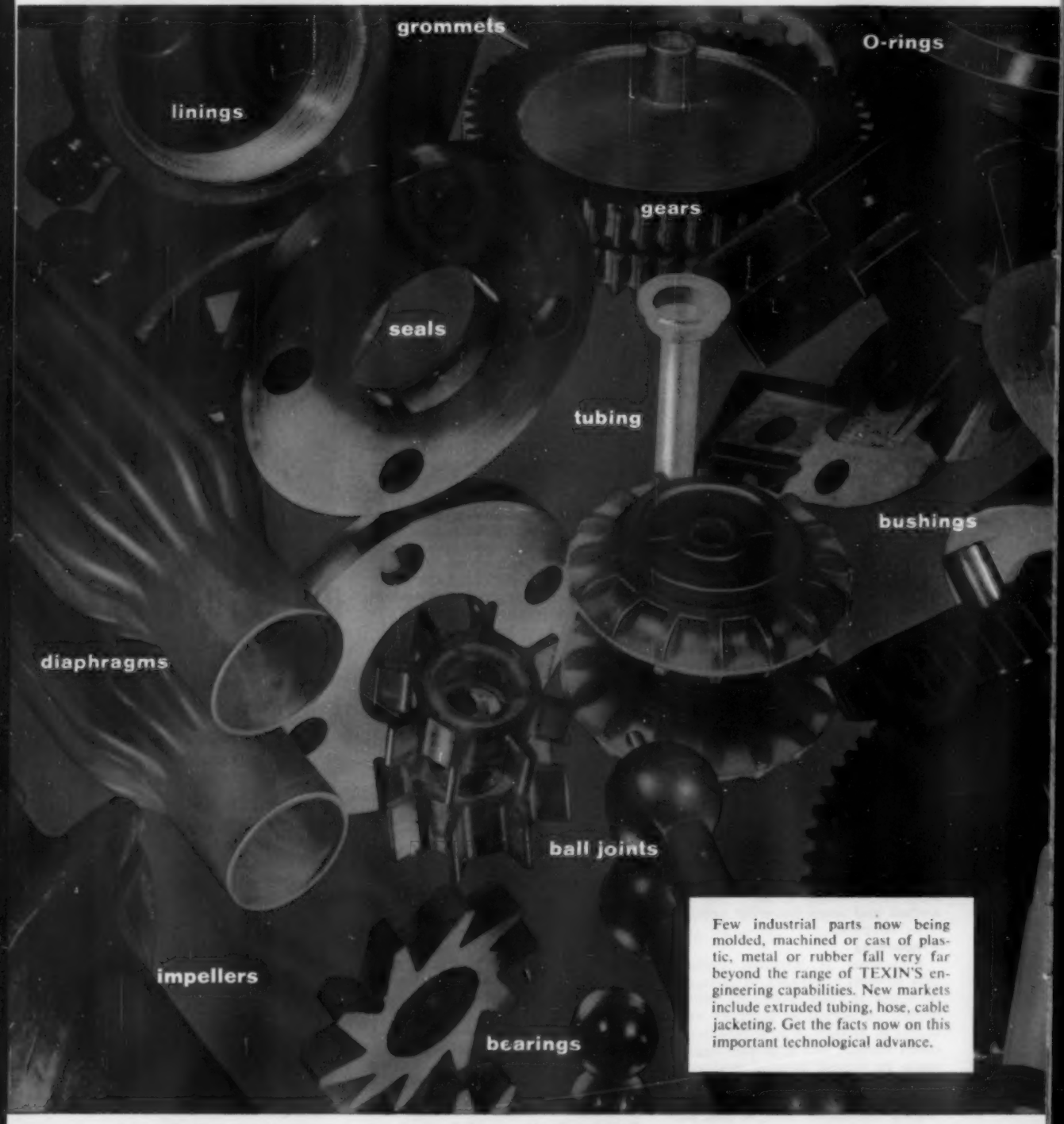

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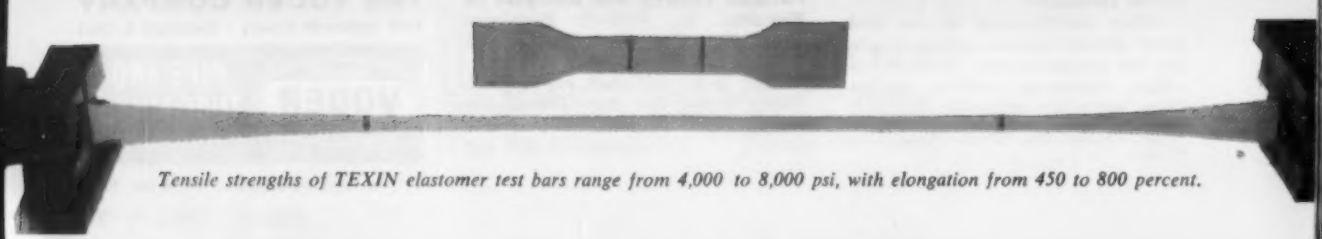

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192 A Molding Grade	1.25	2.7	92–94	44–45	4400 psi	600%	1150	1550	2050	45%	300 lbs.
280 A Extrusion Grade	1.25	2.7	80	—	5500 psi	600%	650	900	1500	30%	—

Send for your copy of Texin Topics, an illustrated bulletin describing the latest application developments in the urethane elastomer field.

**Multrathane is a registered trade name for urethane elastomer chemicals manufactured by Mobay.*

MOBAY

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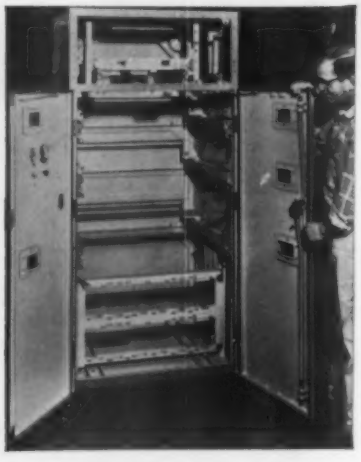
Example . . .



. . . of B & P capability to make lightweight metal assemblies for electronic equipment

Designing and manufacturing products and assemblies of light metals is a highly specialized field. Techniques unknown to production in other metals must be understood and new ones must be developed for unusual requirements.

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The Nike-Hercules system magnesium cabinet shown above is just one example of B & P skill in maintaining close tolerances and optimum precision. Other products and assemblies designed and produced by B & P include . . .

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When you need lightweight products or assemblies for electronic equipment, take advantage of B & P's experience and capability.

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TECHNICAL LITERATURE

(cont'd from p 51)

Atlantic Treaty Organization, should be of special interest to engineers, metallurgists, designers, and others in the aircraft industry. However, anyone interested in fatigue in metals and structures will find useful information.

The book begins with an introductory chapter on symbols and nomenclature. Following chapters discuss fatigue testing methods; fatigue testing machines and equipment; instruments and measuring devices; design, preparation, measurement, and protection of test pieces; factors affecting test results; planning of test programs; and presentation and analysis of results.

Contemporary Problems of Metallurgy. *Edited by A. Samarin. Consultants Bureau Enterprises, Inc., New York. 1960. Cloth, 7 by 10¼ in., 538 pp. Price $16*

This book, translated from the Russian, presents a comprehensive review of the most significant Soviet research in metallurgy.

The major portion of the book deals with recent Soviet advances in the production of steel and pig iron. Other subjects covered include: metallurgy of iron and steel, metallurgy of nonferrous metals, working of metal by pressure, the science of metals, and general problems of metallurgy. Of special interest are the sections on various heat treatments and their effects on heat resisting, austenitic, and stainless steel structures.

Classifications of High Polymers: A review. *R. Houwink and H. Bouman. Butterworth & Co., Canada. 1960. Paper, 6 by 9¾ in., 54 pp. Price $2.25*

A critical examination and review of: 1) classifications based on chemical structure of the polymer; 2) classifications based on the origin of the polymer (or on the chemical structure of the monomer); 3) classifications based on properties or on quality specifications; 4) classifications used by patent documentalists; and 5) alphabetical classifications.

Industrial Finishing Year Book: 1960. *Arrow Press Ltd., 1 Stamford St., London, S.E. 1, England. Cloth, 6 by 9 in., 298 pp. Price $2.10*

Covers workshop practice, protection, cleaning, polishing, electroplating, metal coloring, wood finishes, paint finishes, and paint application.

X-Ray Metallography. *A. Taylor. John Wiley & Sons, Inc., New York. 1961. Cloth, 6 by 9¼ in., 993 pp. Price $27*

This book presents both theoretical and practical information on x-ray metallography, including detailed descriptions of the apparatus and experimental procedures required for the solution of real problems.

Reports

Titanium forgings TITANIUM ALLOY FORGINGS. *H. J. Henning and P. D. Frost. Defense Metals Information Center, Battelle Memorial Institute. Dec '60. 89 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.25 (PB 151100)*

Summarizes current information on the metallurgical, dimensional, and mechanical properties of titanium die forgings Detailed data on typical forgings are presented, and some forging techniques discussed.

Semiconducting materials RESEARCH ON NEW HIGH-TEMPERATURE SEMICONDUCTING MATERIALS. *Available from Dept. of Commerce, Field Services, 350 Fifth Ave., New York 1, N. Y. Price $3*

Summarizes three years of research on the preparation, purification, crystal growth, and fundamental properties of cadmium sulfide (CdS), cadmium selenide (CdSe), zinc telluride (ZnTe), and mixed crystals of cadmium sulfide-cadmium selenide (CdS-CdSe).

Nickel-base alloys PHYSICAL PROPERTIES OF SOME NICKEL-BASE ALLOYS. *M. E. Lanston and C. H. Lund, Battelle Memorial Institute. May '60. 146 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.75 (PB 151086)*

This report on 33 alloys contains definitions of the terms used to describe physical properties, a survey of available data, and data sheets and graphs for each of the representative alloys. A typical data sheet gives a brief description of the alloy, its physical properties, producers, and a list of references from which the data were obtained.

The six alloy groups covered are: nickel-copper, nickel-silicon, nickel-chromium, nickel-chromium-iron, nickel-chromium-cobalt, and nickel-molybdenum.

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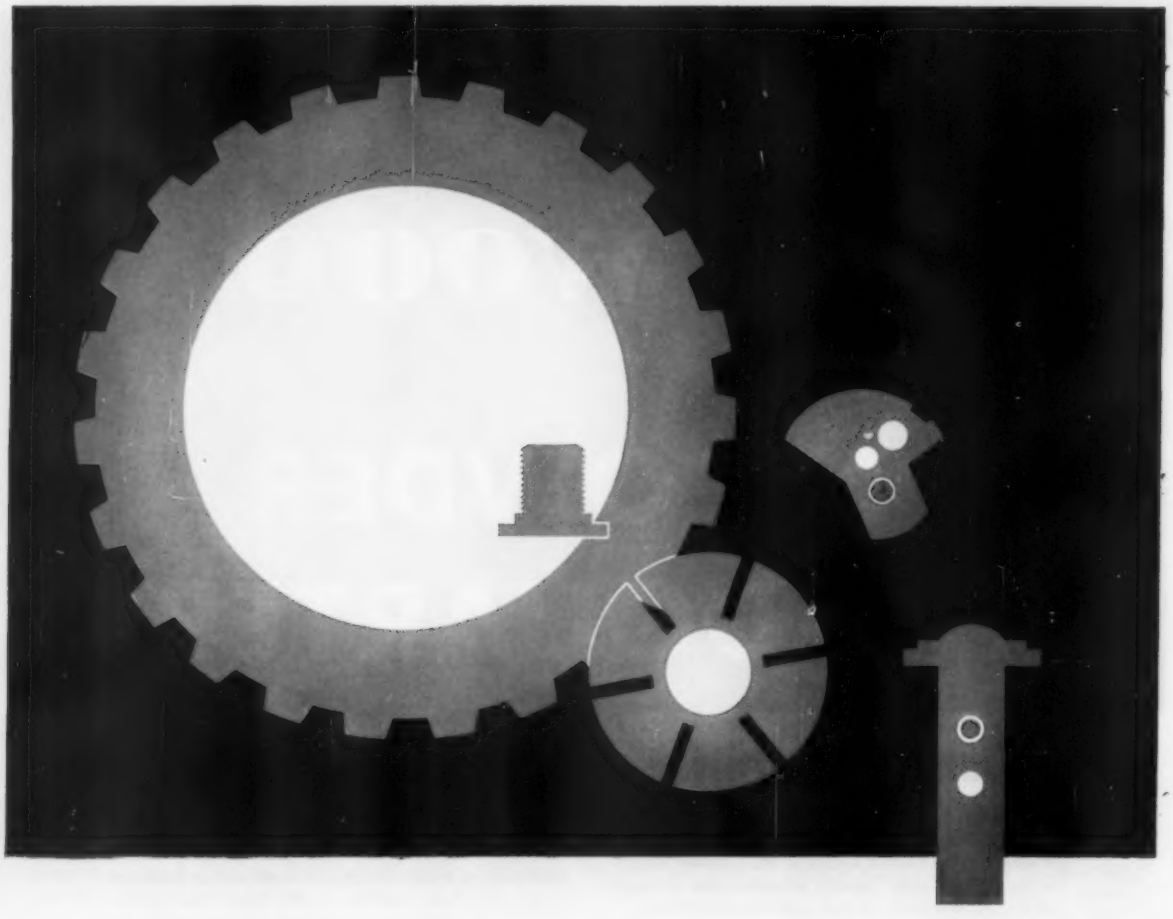

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First Pioneer Award to highlight . . .

17th Annual MPIF Technical Meeting

April 24-26, 1961

The 17th annual technical meeting of the Metal Powder Industries Federation will be held Apr 24-26 at the Sheraton-Cleveland Hotel, Cleveland. The 1961 Powder Metallurgy Show will run concurrently with the meeting. The Powder Metallurgy Seminar will be held again this year. An innovation will be the presentation of the first Powder Metallurgy Pioneer Award.

The awards

The first person to win the MPIF Powder Metallurgy "Pioneer Award" will be Roland P. Koehring, Delco Moraine Div., General Motors Corp. His award will be presented at the banquet on Tuesday evening. The winner of the Irving B. Hexter Powder Metallurgy Award will also be announced then.

The meeting

Seventeen papers on metal powder parts and other aspects of powder metallurgy technology will be presented at this year's technical sessions. All sessions will be held in the Sheraton-Cleveland.

The Federation's business meetings will be held on Monday, Apr 24.

The seminar

The Powder Metallurgy Parts Seminar will be held from 2:00 to 4:30 p.m. on Tuesday. Authorities in the field will participate in an informal discussion of new technological advances, properties and performance characteristics, design features, and other factors influencing the application of powder metal parts. The seminar is open to all attending the meeting. Registration is free.

The show

Company exhibits will be open from 9:00 a.m. to 6:00 p.m. on Tuesday and Wednesday, Apr 25 and 26.

Exhibits will include new compacting presses and sintering furnaces, as well as various metal powders and parts.

Program

Monday, April 24

Business meetings

Tuesday, April 25

9:00 a.m.

Powder Metallurgy Show exhibit opens.

9:00-11:30 a.m.

Chairman—Peter V. Schneider, International Business Machines Corp.

Co-Chairman—William L. Batten, Vanadium-Alloys Steel Co.

Fabrication of Beryllium Sheet from Powder—B. H. Hessler and J. P. Denny, The Beryllium Corp.

Strengthening Effect of Copper in Infiltrated Sintered Iron Parts—E. H. Rennhack, The New Jersey Zinc Co.

High Strength Sintered Parts Made from Titanium Powder—E. P. Weber, Clevite Corp.

Controlled Oxidation Prior to Sintering in Iron and Iron Alloys—H. Harrison and C. G. Johnson, The Presmet Corp.

Effects of Lithium Stearate on Properties of Brass Compacts (Part II)—R. Powell and F. Zaleski, Frankford Arsenal

2:00-4:30 p.m.

Chairman—Robert C. Burgess, Burgess-Norton Mfg. Co.

Co-Chairman—Norbert K. Koebel, Lindberg Engineering Co.

The Handling of Metal Powders for Powder Metallurgical Applications — Arnold Boyce, Delco Moraine Div., General Motors Corp.

1961 Progress Report: **Powder Metallurgy and Metal Powder Industry** — Kempton H. Roll, MPIF

Powder Metallurgy Seminar

6:30 p.m.

Reception and Banquet

Wednesday, April 26

9:00 a.m.

Powder Metallurgy Show exhibit opens.

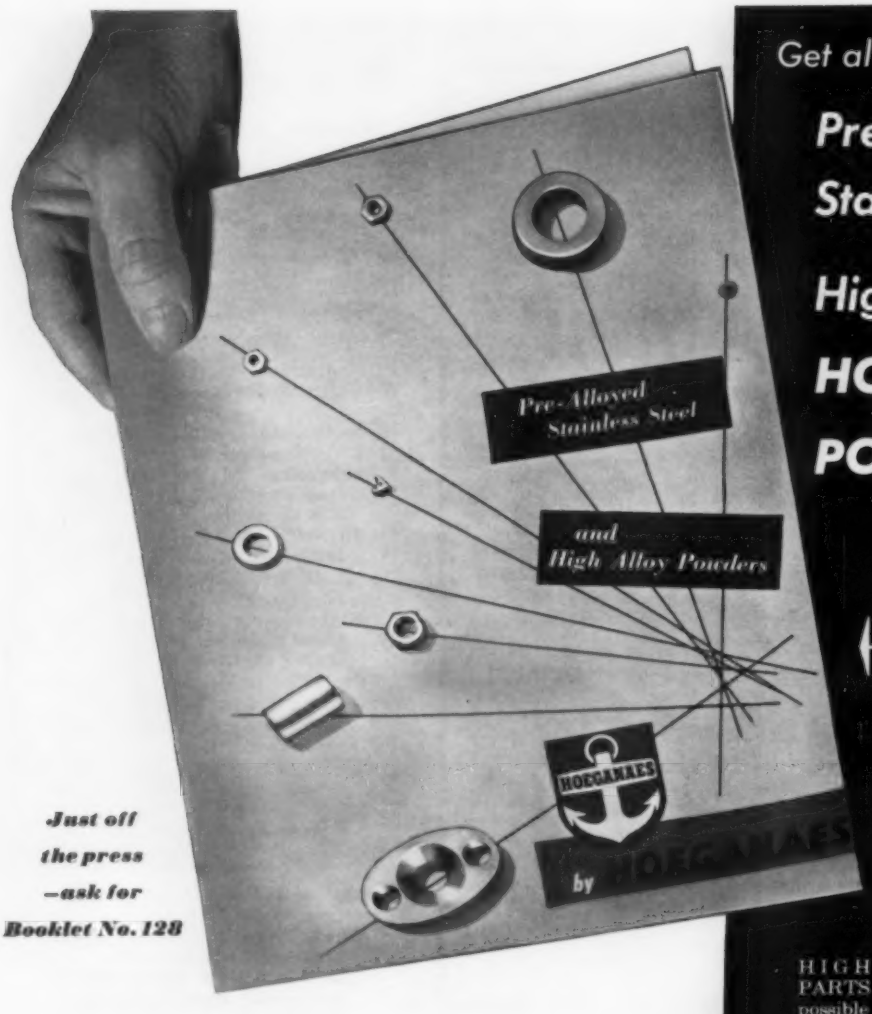
9:00-11:30 a.m.

Chairman—Earl Lowe, Greenback Industries, Inc.

Co-Chairman—Richard S. Gentry, Gentry Carbide Tool & Die Co., Inc.

Today's Tooling — T. Z. Leslie, Micro Carbide Tool & Die Co.

continued on next page



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Be sure to visit **BOOTH 30** *at the* **POWDER METALLURGY SHOW**

Drop in at Booth 30 and we'll talk shop about your high alloy and stainless steel parts fabrication problems. Remember, it's the Sheraton-Cleveland Hotel, on April 24-25-26, 1961.

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POWDER METALLURGY PREVIEW *continued*

A New Approach to the Study of Powder Compaction—R. W. Heckel, E. I. du Pont de Nemours & Co., Inc.

Development and Design of Compacting Presses for the Production of Large Powder Metallurgy Parts—B. B. Belden, Baldwin-Lima-Hamilton Corp.

Electrical Discharge Machining as Applied to Powder Metallurgy Tooling—B. M. Bartlett, Monarch Tool & Gauge Co.

Fundamentals of Powder Metallurgy Lecture: "Creep in Powder Metallurgy Products" — F. V. Lenel, Rensselaer Polytechnic Institute

2:00-4:30 p.m.

Chairman—Carl G. Johnson, The Presmet Corp.

Co-Chairman—Benjamin Falk, Arnold Engineering Co.

New Developments in Furnaces for High Temperature Sintering —N. Koebel, Lindberg Engineering Co.

Grain Oriented 50% Ni – 50% Fe Soft Magnetic Alloys from Metal Powders—N. I. Ananthanarayanan, University of Kansas

Influence of Fabrication Techniques on Electrical and Magnetic Properties of Sintered Metals—A. L. Alves, Engineered Plastics, Inc.

A New Look at Hardness-Strength Relationships in Sintered Metals —R. Talmage, consultant in powder metallurgy

Use and Advantages of Metal Powders in Welding Electrode Coatings—D. J. Schaefer, Champion Rivet Co.

Exhibitors

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American Powdered Metals, Inc.
Associated Equipment Co.
Alan Wood Steel Co.
Baldwin-Lima-Hamilton Corp.
Charles Hardy, Inc.
Drever Co.
Engineered Plastics, Inc.
Federal-Mogul-Bower Bearings, Inc.
Harper Electric Furnace Co.
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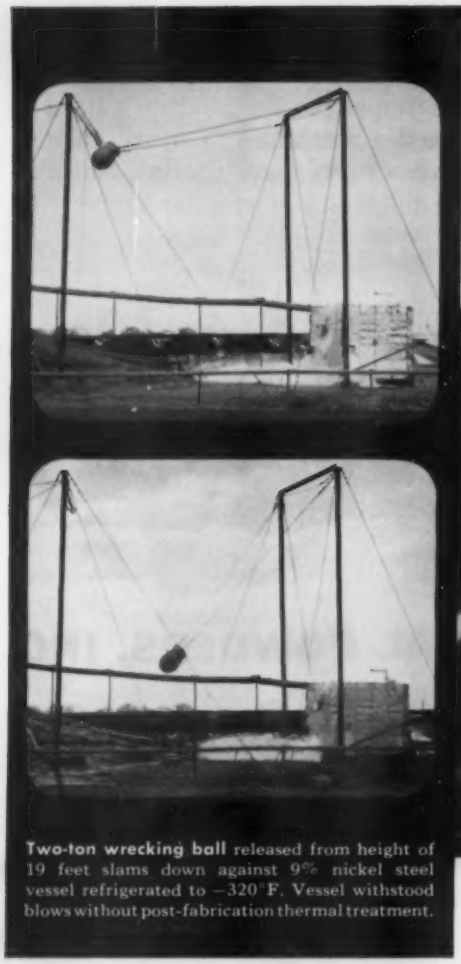

Two-ton wrecking ball released from height of 19 feet slams down against 9% nickel steel vessel refrigerated to −320°F. Vessel withstood blows without post-fabrication thermal treatment.

IMPACT in "Operation Cryogenics"! At U.S. Steel's Fairless Works, over 82,000 ft-lb blow puts 9% nickel steel vessel to test far more severe than service conditions. "Operation Cryogenics" is a cooperative program of U.S. Steel Corp., Chicago Bridge & Iron Co., and Inco.

9% Nickel steel wins giant hammer test at −320°F

"Operation Cryogenics" proves 9% Nickel steel vessels need no thermal treatment after welding

Imagine the tremendous impact when this two-ton wrecking ball swings down through a long arc and smashes against the steel tank!

Certainly brutal punishment at ordinary temperatures . . .

But in this test the tank was filled with liquid nitrogen and held *at 320 degrees below zero Fahrenheit.*

At this ultra-cold temperature, many materials become brittle and shatter under impact. But steel containing 9% nickel remains tough and ductile. In fact, the yield and tensile strengths of 9% nickel steel actually *increase substantially* as temperature is lowered.

In test after test, the pressure vessels —not thermally treated after welding— withstood massive impacts as high as 82,000 ft-lb.

These tests prove that 9% nickel steel, without thermal treatment after fabrication, provides the high strength and toughness for safe, economical pressure vessels to contain and transport low-temperature liquids.

When you order, design, or build equipment for production, storage, or transport of liquefied gases at temperatures down to −320°F, specify 9% nickel steel for safety and economy. And for engineering data on 9% nickel steel, and other steels for low-temperature service, write to Inco.

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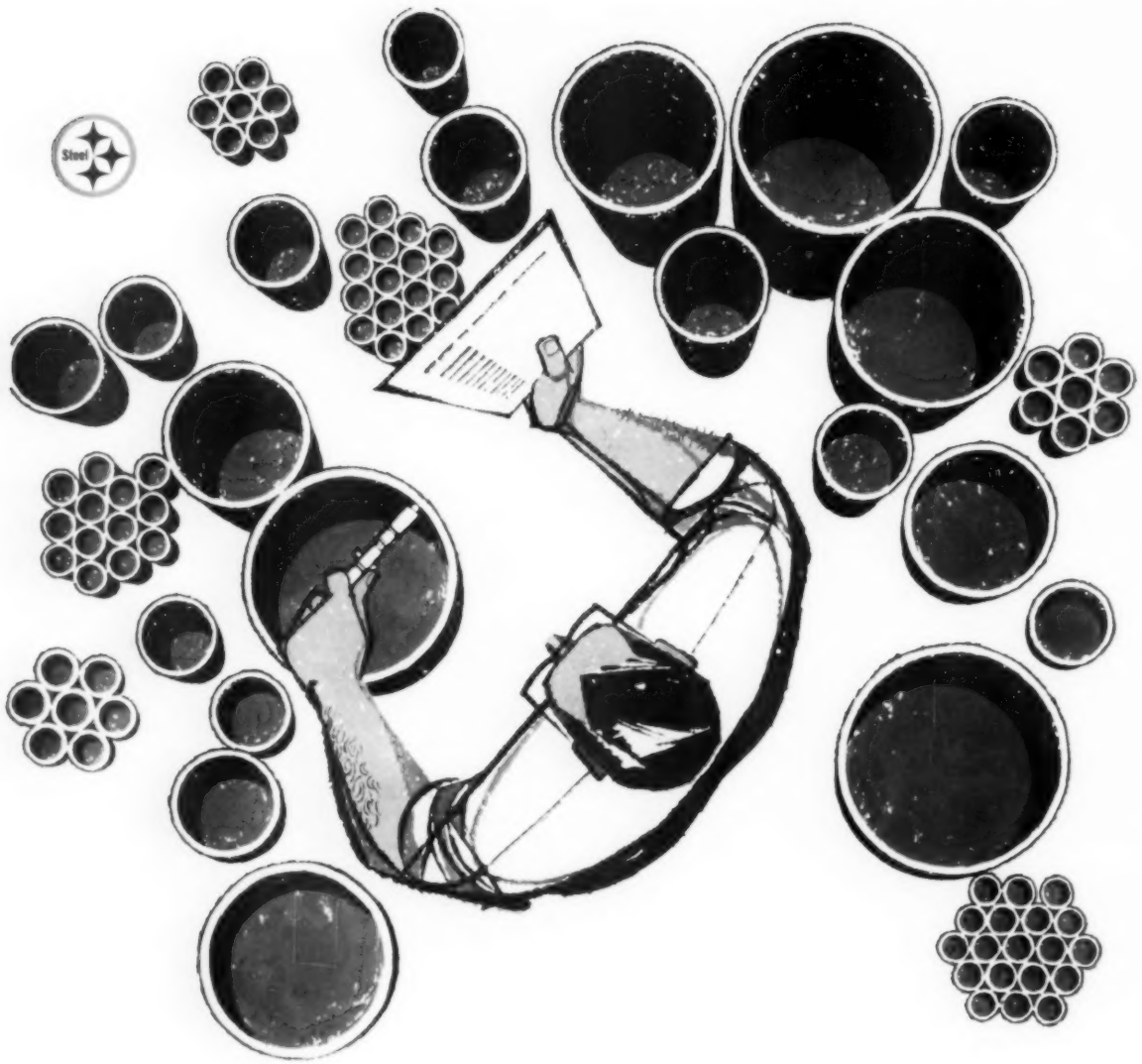

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$10,000 per year are saved by the manufacturer of this hydraulic jack since he converted the 16 inch long caster bar to a Malleable casting. The bar originally was a fabricated part that required shearing, punching, sawing, chipping, grinding and reaming, plus welding at eight points. The Malleable casting is delivered ready-to-use at a savings of $2.68 per unit.

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Wagner Castings Company, Decatur

INDIANA
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IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

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MINNESOTA
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Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

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How wood engineering helps this ship do the work of a fleet

THIS SHIP — the METHANE PIONEER — is the only one in the world that has ever transported a cargo of liquid methane across the ocean — and she's done it regularly.

It would take 600 ships like this one to transport a load of liquid methane in its natural, gaseous form! By bringing its temperature down to –258°F. at atmospheric pressure, the methane is liquefied to a small fraction of its original volume.

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Problems like this are "all in a day's work" to the wood engineers at Gamble Brothers—a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

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FREE booklet illustrates GAMBLE services

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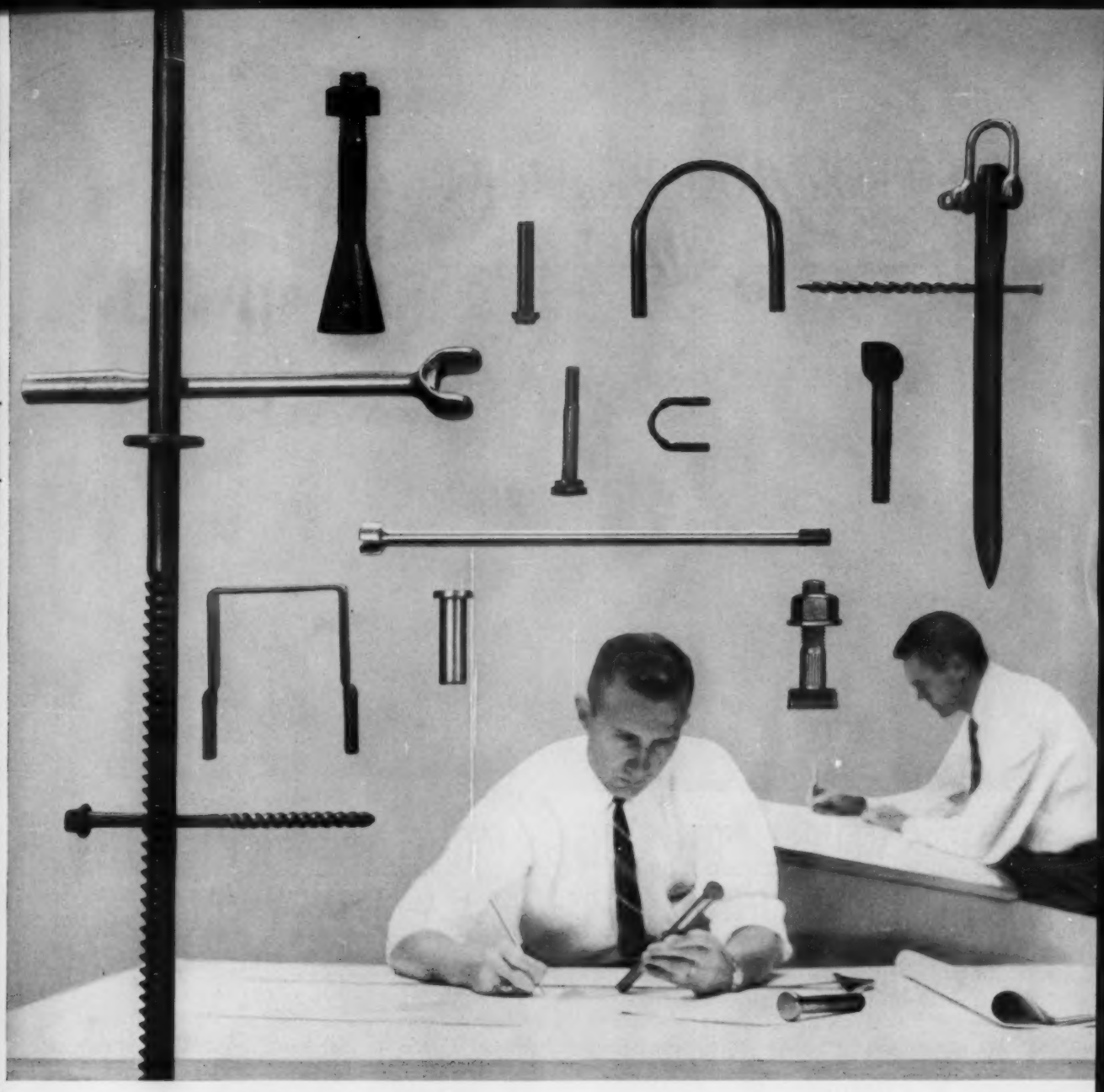
If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GB GUARANTEED BOND

GAMBLE BROTHERS, INC.

4627 Allmond Avenue, Louisville, Kentucky

For more information, turn to Reader Service card, circle No. 397



Bethlehem makes "specials" to your specification.

And we often cut costs by redesigning to improve the product.

Every one of these specialty products was made for a specific application from drawings or specifications supplied by our customer. Translating your design into a finished part is seldom easy. But if the job can be done . . . Bethlehem fastener engineers can do it.

Let us know what you need. Our fastener engineers will study your requirements and give you an honest answer on what we can do. For more information call the nearest Bethlehem sales office. Or write to us at Bethlehem, Pa.

Steel

for Strength
... Economy
... Versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 368

NEWS FROM GOODRICH-GULF

NEW SYNTHETIC RUBBER CAN REPLACE NATURAL 100% IN HEAVY DUTY TIRES

Goodrich-Gulf is now proceeding with a multi-million dollar plant for the commercial production of Ameripol CB (cis-polybutadiene) rubber. CB is the only known polybutadiene rubber which can be used as a 100% replacement for natural rubber in heavy duty tire treads.

In over 5 million miles of test driving on Ameripol CB tire treads, up to double the tread life of natural rubber has been achieved. Superiority is greatest in very severe conditions including heavy loading, long distances, and high-speed turnpike driving.

The first Goodrich-Gulf plant unit will produce at an annual rate of 20 million pounds. In addition, other companies will produce CB under license.

Ameripol CB has qualities which may be advantageous in applications beyond tires. Good electrical properties, abrasion resistance can provide superior coverings for electrical wires that are subjected to mechanical wear. Outstanding flex properties suggest superior performance in power transmission belting and conveyor belting.

This new development complements Goodrich-Gulf's production of Styrene-Butadiene Rubber (SBR) in non-pigmented hot, cold, and oil-extended types; and micro-black masterbatch cold, and cold oil-extended types.

Ameripol
THE PREFERRED RUBBER

PROCESSING COSTS CUT WITH NEW MEDIUM-LOW VISCOSITY SBR

Newest addition to the Ameripol SBR family, Ameripol 4604, has the combined features of a high bound styrene with a minimum-low raw Mooney viscosity in the range of 30 to 42.

The high bound styrene content, together with medium-low viscosity, results in a cold polymer with excellent processing characteristics. Time is saved, and need for peptizing agents is eliminated.

TYPICAL PHYSICAL PROPERTIES

(Based on test recipe of 100.0 parts Ameripol 4604, 40.0 parts EPC Black, 5.0 parts zinc oxide, 1.5 parts stearic acid, 2.0 parts Benzothiazyldisulfide, 2.0 parts sulfur).

Raw Viscosity, ML-4 @ 212°F.		40
Compound Viscosity, ML-4 @ 212°F.		51
	Cure @ 292°F.	
Tensile, psi	50′	3080
Elongation, %	50′	745
Modulus, 300%, psi	25′	310
300%, psi	50′	830
300%, psi	100′	1260

Light color, low viscosity, outstanding physical properties, and low water absorption qualify Ameripol 4604 for products such as:

Closed Cell Sponge • Calendered Goods • Open Cell Sponge • Transfer Molded Items • Cements • Coated Fabrics • Adhesives • Hard Rubber

AMERIPOL 4700 CUTS FLOOR MAT COST

Each one of these automobile floor mats coming down the conveyor line at Anchor Industries, Inc., Cleveland, represents a savings over the previous rubber polymer used.

The mats are made from Ameripol 4700, which is a 50-part oil-extended rubber; thus costs substantially less than low-oil polymers. Ameripol 4700 maintains the high quality level this company has established; permits processing in a range of colors.

Since Goodrich-Gulf produces the broadest range of SBR polymers, we are in excellent position to help you in selecting the type which exactly meets your needs.

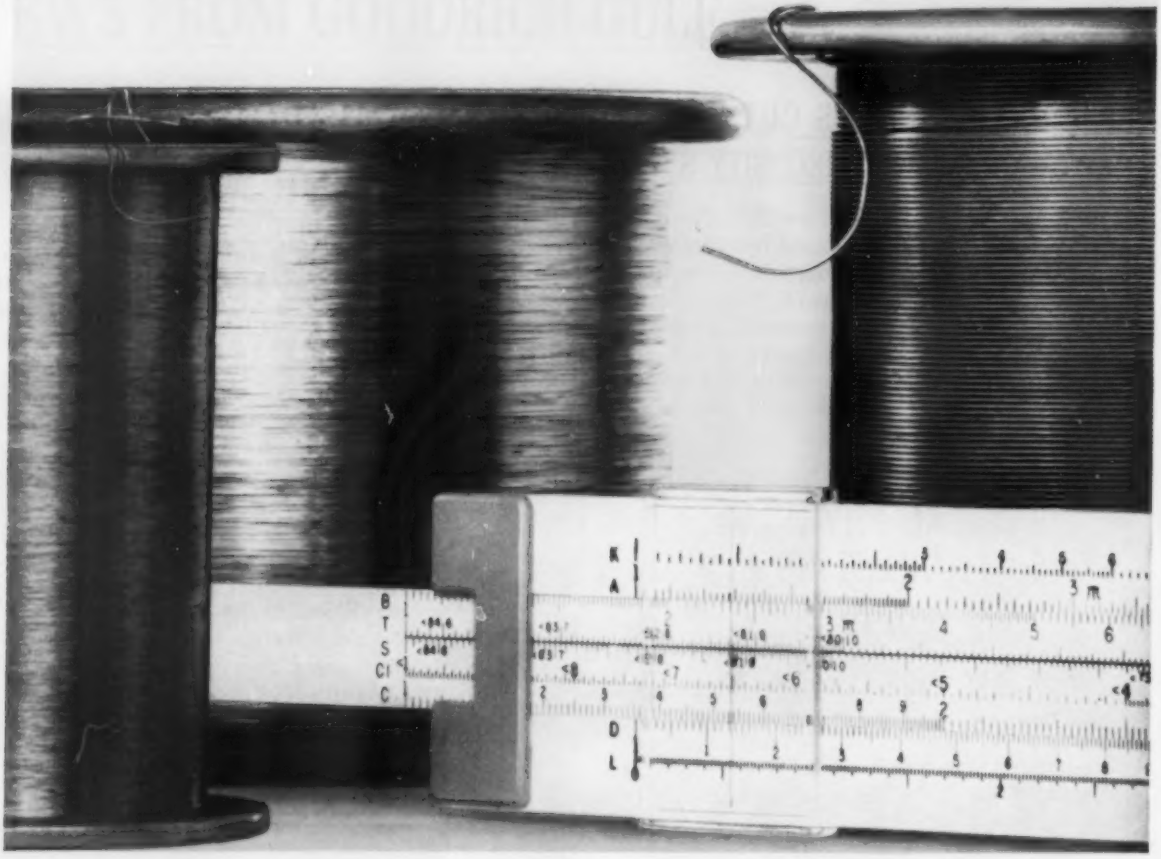
For information, write: 1717 East Ninth Street, Cleveland 14, Ohio

Goodrich-Gulf Chemicals, Inc.

WORLD'S LARGEST SOURCE OF SYNTHETIC RUBBER

For more information, turn to Reader Service card, circle No. 374

SYLVANIA MAKES ALL THREE—ALLOY, CLAD AND PLATED WIRE



One way to conserve engineering time

—get an unbiased recommendation on wire from Sylvania

Rapid changes in high-temperature equipment plus the continued evolution in components mean this: it doesn't pay to get mired down by noncreative engineering details. Example: which wire to use to meet conductivity needs in corrosive or oxidizing atmospheres?

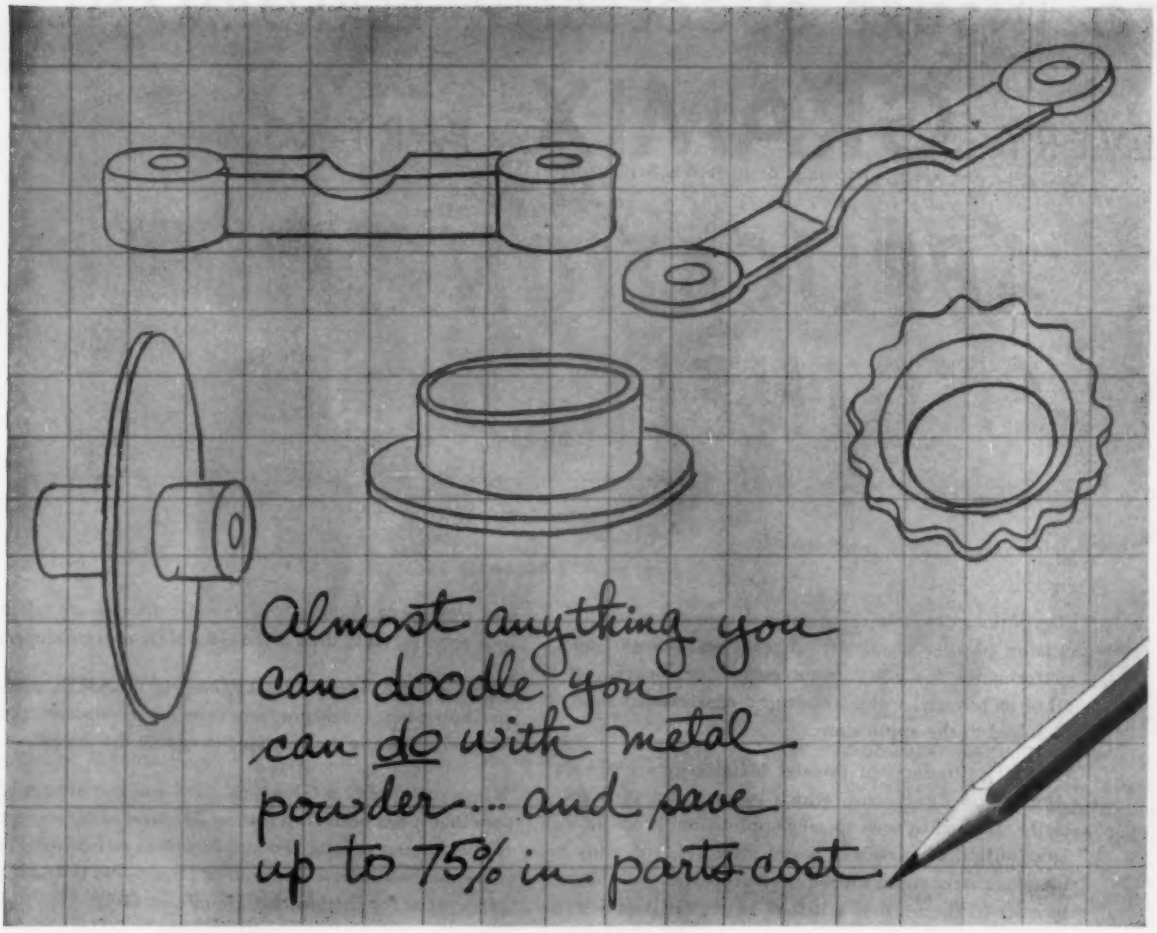
To make the most of your engineering time, call on *Sylvania* to help you with wire specs. Sylvania knows wire—and the particular advantages of each kind. Of all major manufacturers, only Sylvania makes all three types of bare wire—alloy, clad and plated. They're available in a complete range of sizes—.002″ to .250″. Each retains optimum characteristics up to recommended operating temperatures.

You know that a Sylvania recommendation will be objective, based on your needs, and not limited by what the supplier can supply. Full details—plus time saving help—are yours when you write Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

For more information, turn to Reader Service card, circle No. 326



Many of the parts on your drawing board and on your production line can be made with versatile metal powders . . . made faster, better and at lower cost than by other fabrication methods.

Powder metallurgy means shorter tooling time, greater production rates, less scrap and use of a greater variety of materials. Your precision parts can have improved finish, appearance and performance characteristics.

Glidden supplies metal powders to the best fabricators in the field. Let us show you how to obtain superior parts at up to 75% less cost.

QUALITY Glidden PRODUCTS

RESISTOX METAL POWDERS

The Glidden Company
Chemicals Division • Metals Department
Hammond, Indiana • Johnstown, Pennsylvania

Send us sketches of your parts, and we will get you no-obligation quotations from qualified fabricators.

FREE technical bulletins

THE GLIDDEN COMPANY
Chemicals Division, Metals Department
Hammond, Indiana

Please send me complete specifications on the Glidden products I have checked below.

- ☐ Copper powder
- ☐ Copper pigment
- ☐ Cuprous oxide (red)
- ☐ Cupric oxide (black)
- ☐ Cuprous sulphide
- ☐ Tin powder
- ☐ Lead powder
- ☐ Cubond copper brazing pastes

Name_____ Title_____

Company_____

Street_____

City_____ State_____

For more information, turn to Reader Service card, circle No. 346

TO INSURE SUCCESSFUL PERFORMANCE

EVERY GRAMIX® PART IS

(PRODUCTS OF POWDER METALLURGY)

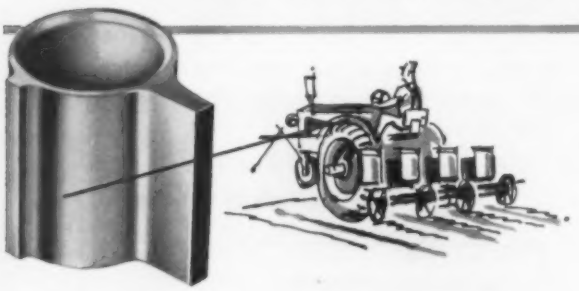
APPLICATION ENGINEERED

One of the most important factors to consider when purchasing powder metal parts is that of successful part performance; for a part to successfully perform its job, all of its physical and metallurgical characteristics must be suited to the application.

GRAMIX Products of Powder Metallurgy are always *Application Engineered,* which means product is specially matched to each specific application. From an almost unlimited variety of metal mixtures, one alloy is blended that contains the required properties and characteristics of the finished part; *all* aspects of part design and conditions under which it must operate are taken into account. Only then is the GRAMIX part produced.

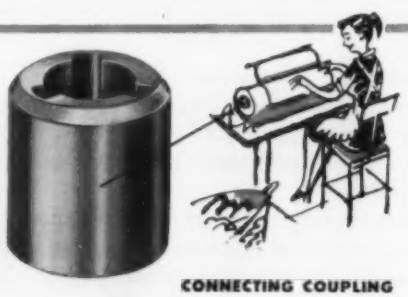
Eight of these *Application Engineered* GRAMIX parts are shown here. Each precisely suits the requirements of its job . . . each is the best part available for the job.

When you specify a GRAMIX part, you can always be sure that it has been *Application Engineered* for successful performance, long life and complete reliability. For more information on *Application Engineered* GRAMIX parts, write for Engineering Handbook G-55.



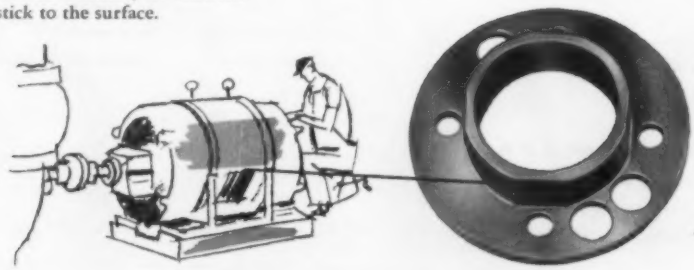
CORN SEEDER

GRAMIX was the material specified for this corn seeder part because the surface finish obtainable with the alloy used reduced the tendency of material to stick to the surface.



CONNECTING COUPLING

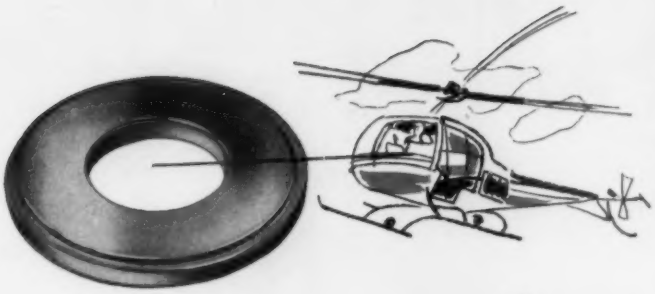
The connecting coupling employed in a small home ironer is formed from a special GRAMIX hardened steel alloy; it offers low wear and shock resistance.



CONTAINER COVER END CAP

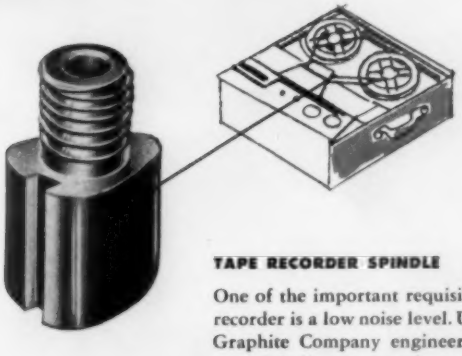
Great savings were realized when retainer caps for certain types of electric motors were made of GRAMIX.

This process made it simple and economical to mold the multiple holes to precise tolerances without extra operations.



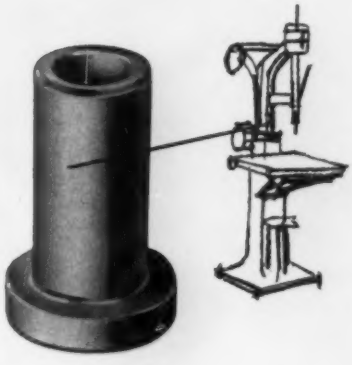
HELICOPTER THRUST WASHER

The outstanding features of the GRAMIX alloy specified for this thrust washer are a dependable and consistent friction and wear pattern as well as a fine surface finish.



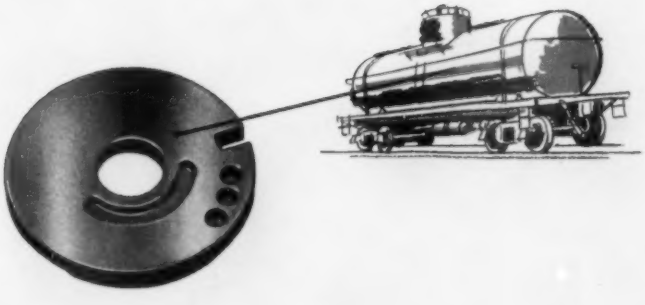
TAPE RECORDER SPINDLE

One of the important requisites in a tape recorder is a low noise level. United States Graphite Company engineers developed a special alloy to meet these requirements in the GRAMIX spindle.



GUIDE BEARING

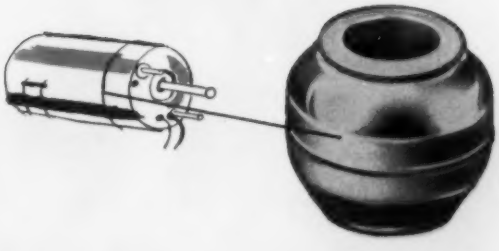
Built-in lubrication and low friction to reduce heat are important features of the GRAMIX alloy chosen for this guide bearing.



LIQUID PUMP END PLATE

This end plate is typical of many parts employed in liquid pumps of many types.

It is made from a wear resistant bronze alloy that was developed for pump applications.



FRACTIONAL H.P. MOTOR

The GRAMIX bearing for this Fractional h.p. motor was developed from a special low noise level alloy.

Its self-lubricating properties were also an important consideration in specifying GRAMIX.

METAL POWDER mpi INDUSTRIES FEDERATION

X-296-2

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

For more information, turn to Reader Service card, circle No. 419

Joe Foster, President, suggests the range of Foster Grant's engineering services.

"Help design molds for a customer? Sure, and we can production-prove them for you, too," says Joe Foster.

Not that designing molds is our business.

Basically, we're suppliers of polystyrene, impact polystyrene and Nylon 6 resins, and we're also the world's largest manufacturer of sunglasses. But quite often a customer takes us up on our standing offer — of technical assistance in any area, from materials and machines to packaging and marketing.

Take last Fall, for instance. One of our customers was in Leominster, so we invited him to drop over and see our facilities. He molds combs, and one glance convinced him that some of our ideas might make his operation more productive.

We then offered to furnish him an improved mold, designed for his needs and tested by us **on his own machines.** Result — he now gets 16 combs per "shot" instead of 8, semi-automatic instead of hand de-gating, and a 26% shorter cycling time. No more grinding or buffing, either... for a yearly saving of more than $100,000!

Why not see if our engineering services can help **you.** Call or write us today. Foster Grant Co., Inc., Leominster, Mass., KEystone 4-6511.

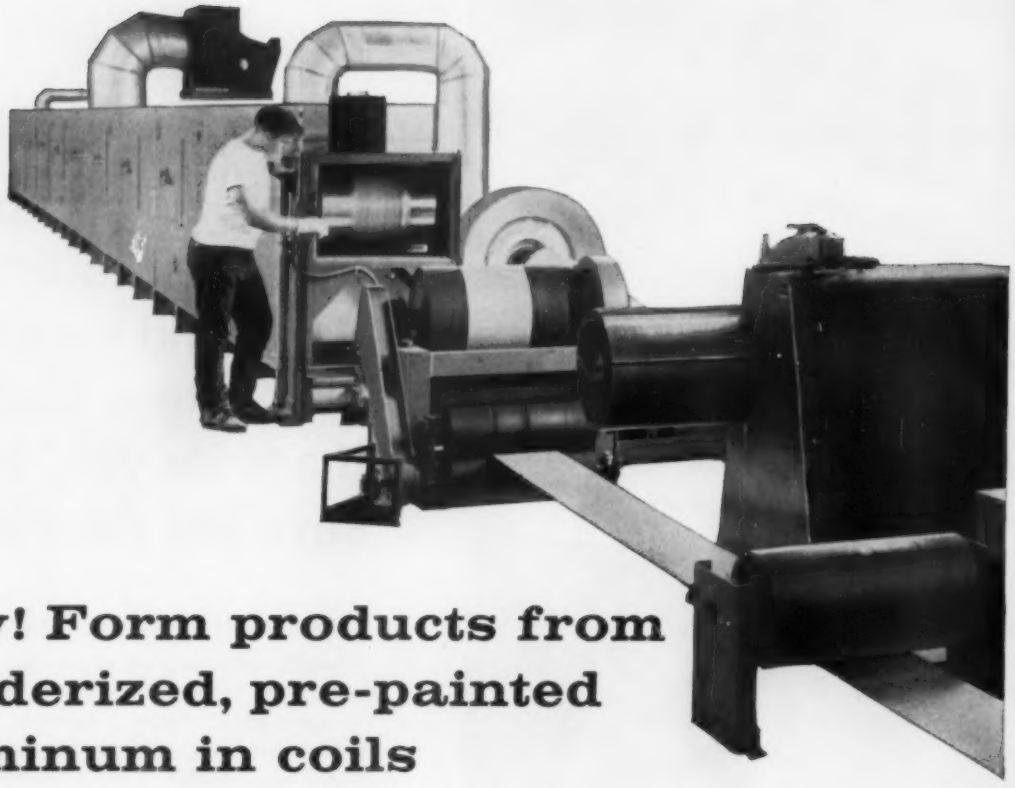
FG®

FOSTER GRANT

Your Partner in Plastics Progress

Plants in Leominster, Mass., Manchester, N. H., Baton Rouge, La.
Branch Offices and Warehouses in principal cities
Also distributed by H. Muehlstein & Co., New York, N.Y.

For more information, turn to Reader Service card, circle No. 423



Now! Form products from Bonderized, pre-painted aluminum in coils

A modern, new way to better products at lower manufacturing cost. Use Bonderized aluminum coil stock with baked-on paint, ready for fabricating.

Automated straight-line production assures uniform Bonderized and roll coat painted coil meeting the highest quality control standards.

The Bonderite coating on aluminum stock accomplishes the double job of controlling corrosion and anchoring the paint. Paint adhesion is so spectacular that the most severe forming operations can be accomplished without finish failure.

Service life of paint over Bonderized aluminum is five to ten times that on untreated aluminum!

Improve manufacturing efficiency, product performance and customer satisfaction by forming your aluminum products from Bonderized, pre-painted coil stock. The Parker representative has complete, helpful information for you.

Since 1914— leader in the field

Parker Rust Proof

2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base | BONDERITE and BONDERLUBE aids in cold forming of metals | PARCO COMPOUND rust resistant | PARCO LUBRITE—wear resistant for friction surface

*Bonderite, Bonderized, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

PROTECTED BY Bonderite PARKER RUST PROOF CO. QUALITY CORROSION RESISTANT

The Bonderite seal is a recognized mark of quality

- Siding
- Shingles
- Roofing
- Architectural panels
- Gutters and downspouts
- Partitions
- Storm and screen frames
- Windows
- Awnings
- Cabinets
- Mobile homes

. . . a few of many aluminum products now being made from Bonderized painted aluminum coil stock.

Photo courtesy KEYSTONE ALLOYS COMPANY

Company

TROPICAL—heavy duty maintenance paints since 1883

For more information, turn to Reader Service card, circle No. 379

Report from Carborundum:

How industry is solving unusual problems with unusual refractories

PACKING EXPANSION JOINTS:

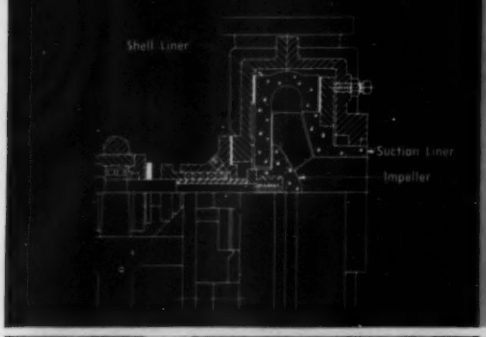
CERAMIC FIBER WITHSTANDS 2300°F; EASILY PACKED; OBTAINABLE IN MANY FORMS. FIBERFRAX® ceramic fiber extends the temperature ceiling of fibrous insulating materials; opens new application areas. In rope or bulk form, it makes an excellent expansion-joint packing for refractory furnace walls. It is light in weight, highly resilient, does not shrink, is impervious to heat shock, and is inert to most furnace atmospheres. Various forms of FIBERFRAX — e.g. cloth, board, paper etc. — also offer advantages for gasketing, sealing, wrapping, lining, encapsulating, blanketing and jacketing.

ZINC ORE REDUCTION IN VERTICAL RETORT:

RUGGED REFRACTORY WALLS CONDUCT HEAT FAST, STAY GAS TIGHT. Five million Btu's must be transferred through refractory walls such as shown at left for every ton of zinc produced. High heat conductivity — 11 times that of firebrick — is provided by CARBOFRAX® silicon carbide retort walls. Internal temperatures reach 2000°F. Other important refractory properties: great physical strength at high temperatures, chemical inertness, and unequalled abrasion and erosion resistance. Low permeability is also important because gas-vapor mixtures produced in the retort must be contained.

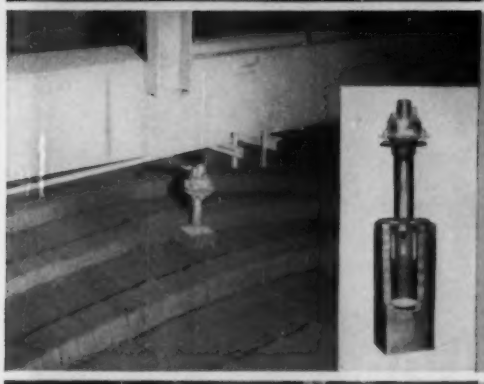
SPRAY NOZZLE FOR CORROSIVE SERVICE:

REFRACTORY REPLACES METALS—RESISTS HIGH TEMPERATURES, CORROSION, THERMAL SHOCK. The nozzle illustrated sprays a 15% solution of SO_2 in water at 150°F into a chamber operating at over 1700°F. Conditions involve severe thermal shock and corrosion. Previously used metal nozzles often lasted less than two months. Nozzles made of Carborundum's silicon carbide have shown no signs of failure after five years of service — another example of how these versatile refractories can take unusual forms to meet highly specialized problems.



PUMPING ABRASIVE SLURRIES:

REFRACTORY PARTS FOR PUMP RESIST WEAR, OUTLAST HARDEST METAL ALLOYS. Development of REFRAX®, a silicon-nitride-bonded silicon carbide, makes it possible to use refractories in many applications usually requiring metals. It can be formed with high dimensional accuracy as well as a high finish. Examples of use are impellers and shell liners in "Lightning" sand and gravel pumps made by Kansas City Hay Press Co. Comparative performance during a six months' test pumping 150 GPM of water with 20% silica sand against a 70-foot head has shown that REFRAX parts give more than five times the life of duplicate parts made of nickel chrome alloy.



MAKING 200 TONS OF STEEL BEHAVE:

TARGET BLOCK HELPS KEEP FURNACE TEMPERATURE AT MAXIMUM PRODUCTION LEVEL. The temperature detector shown in the open hearth roof at left is mounted in a hollow silicon carbide block. The detector is focused on a target disc made of another one of Carborundum's refractories — REFRAX refractory. Radiated heat from the disc provides a constant check on roof temperature . . . assures maximum production without danger of "losing" the roof. These two refractories provide the necessary properties of high heat conductivity, resistance to high temperatures and furnace gases and exceptional hot strength. Device is manufactured by Leeds & Northrup Co.

FIRING ELECTRICAL PORCELAINS:

SILICON CARBIDE KILN FURNITURE SIMPLIFIES CAR SETTINGS, PROTECTS WARE; IMPROVES HEAT CIRCULATION. Kiln car at left is loaded with electrical insulators supported by CARBOFRAX silicon carbide tile, posts and girders. Setting enables car to carry maximum load; may be rearranged as needed to suit different sizes of ware. CARBOFRAX furniture possesses high hot strength, resists deformation, reduces breakage losses — in trip after trip through the kiln. Furniture is also designed to permit uniform circulaton of heat through and around car for best ware firing conditions.

SINTER-PLANT DUST COLLECTOR:

REFRACTORY LINING LASTS YEARS IN SERVICE INVOLVING HIGH-VELOCITY GAS AND ABRASIVE PARTICLES. Superior resistance to entrained abrasive particles is shown by a lining made of a Carborundum-made refractory in this primary dust collector. Cone lined with Carborundum's material has handled more than 2,500,000 lbs of abrasive sinter dust in seven years. Ordinary brick in other parts of the same collector has worn back to the shell in only 5 months. Other wear-resistant applications for Carborundum's refractories are in duct linings, blast furnace downcomers, hydro cyclones, chutes, bins, feeder tables, gas scrubbers, nozzles and other related applications.

Want help on your problems? Carborundum engineers will be glad to recommend refractories to answer your specific needs. For information, contact Dept. MD-41, Refractories Division, Carborundum Co., Perth Amboy, N. J. Descriptive brochures available on request. Please specify the area or areas of particular interest to you.

for engineered refractories . . . count on

CARBORUNDUM®

The American Hot Dip
Galvanizers Association
with the cooperation of
The American Zinc Institute
Announces the $10,000.

Galvanizers' International

Ten Awards of $1,000. Each

Ten awards are to be made to entrants selected by the judges. Each award will consist of $1,000 in cash, a suitable medal and a Certificate of Achievement.

This is not a contest—it is a search for new ideas. ■ *Your entry, therefore,* will not be judged against others, but solely on its merit and value in developing new applications and markets for Hot Dip Galvanizing. ■ If your idea, in the opinion of the judges, is of practical value to the industry, you will be cited for an award—promptly. ■ Because the Hot Dip Galvanizing Industry is anxious to receive ideas of this type, the judges reserve the right to present *more* than 10 awards, if the entries warrant.

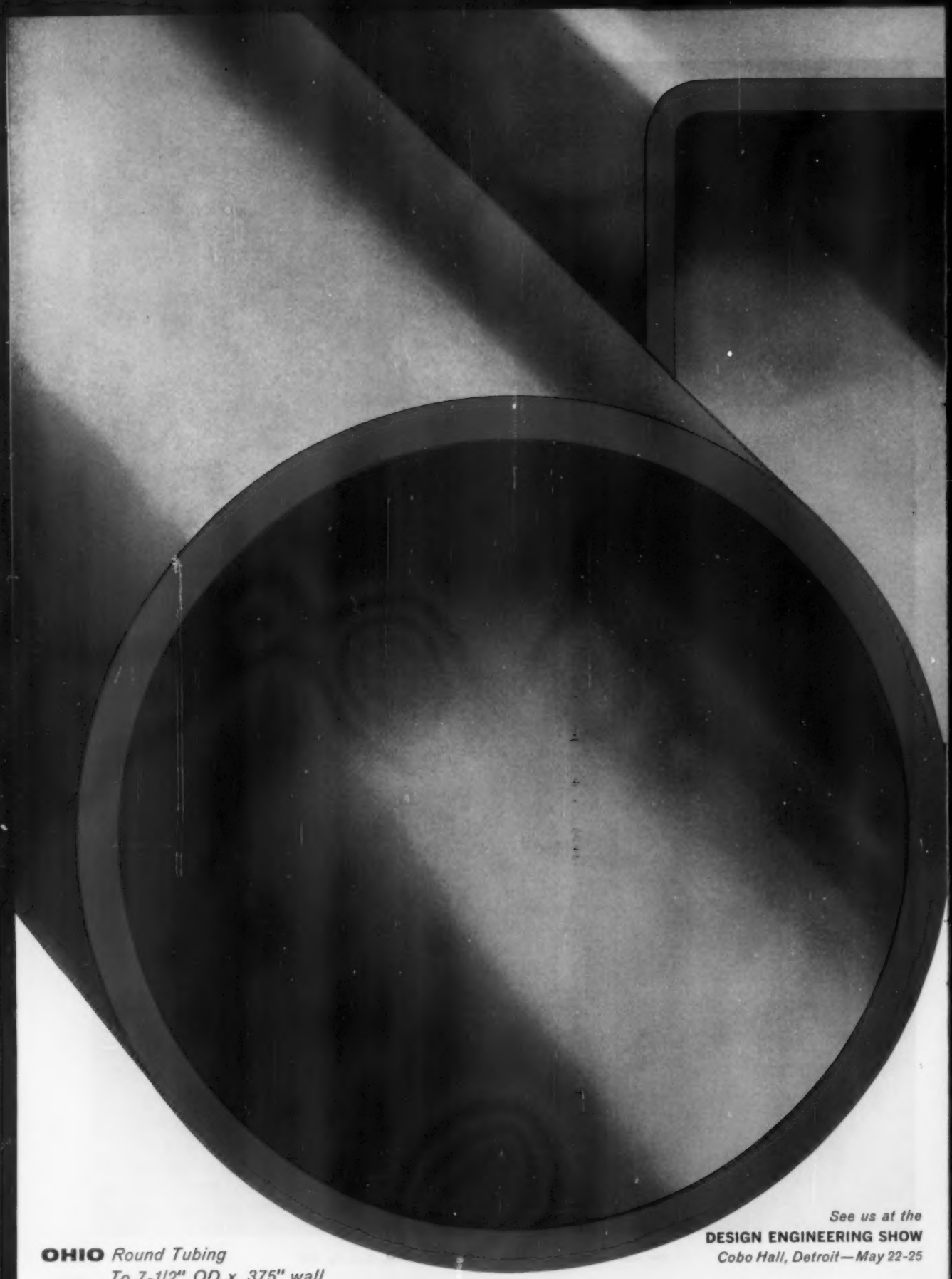
CONDITIONS ■ Anyone in the world (except members of the American Hot Dip Galvanizers Association and the American Zinc Institute, and their employees and advertising agencies) may submit one or more entries. ■ Entries will be considered by the judges promptly upon their receipt. No entry received after April 30, 1962 will be considered. ■ The Awards will be made for ideas pertaining to: (a) Applications of Hot Dip Galvanizing to a *new or unusual* field, or; (b) An *improvement* in application in fields where Hot Dip Galvanizing is now being used, or; (c) New methods of *after-treatments* of Hot Dip Galvanized products. ■ Each entry submitted must contain: (a) Description and documentation of application. (b) Case history of the application or process accompanied by photo, drawings, formulae, etc. (c) All technical data needed for the utilization of the idea submitted. (d) Release of the application or idea for general use without payment or royalty other than the $1000 award. ■ The decision of the judges will be final. Award-winning ideas will be retained by the American Hot Dip Galvanizers Association for dissemination throughout industry. Other entries will be returned. ■ No formal entry blank is required but the entry should be accompanied by the name, address and business connection of the individual submitting it. Business firms or corporations may submit entries under their business name, instead of as individuals, if they choose to do so. ■ Entries should be sent to: AMERICAN HOT DIP GALVANIZERS ASSOCIATION, INC., 5225 Manning Place, N.W., Washington 16, D. C. ■ *Note:* For information on galvanizing write to the above address for name and location of the American Hot Dip Galvanizers Association member nearest you.

Awards

FOR ACHIEVEMENTS IN RESEARCH, DEVELOPMENT AND UTILIZATION OF GALVANIZED PRODUCTS

THE JUDGES ■ Dr. Clarence H. Lorig, Technical Director, Battelle Memorial Institute and Past President American Society for Metals. ■ Mr. John R. Daesen, Technical Director, American Hot Dip Galvanizers Association. ■ Mr. John L. Kimberley, Executive Vice President, American Zinc Institute.

For more information, turn to Reader Service card, circle No. 357



OHIO *Round Tubing*
To 7-1/2" OD x .375" wall

See us at the
DESIGN ENGINEERING SHOW
Cobo Hall, Detroit—May 22-25

A-3573A

OHIO *Square Tubing*
To 6" x 6" x .259" wall

OHIO *Rectangular Tubing*
To 7-1/2" major diameter x .259" wall
Typical 4" x 6" x .259" wall section illustrated

Announcing Mechanical — Pressure — Cold Drawn

OHIO QUALITY WELDED STEEL TUBING

in larger sizes...heavier wall thicknesses

OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • **SHELBY, OHIO**

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

New sizes and heavier wall thicknesses of Ohio Quality Welded Steel Tubing (up to 7½" OD) now parallel the sizes of famous Ohio Seamless Steel Tubing. That means — now more than ever — there's a type and size of Ohio tube to fit your special requirements exactly. And since we make both types, we're in a position to recommend the best type for your own particular needs. Ohio Tubing — either welded or seamless — is just "made to order" for your product.

For more information, circle No. 339

Cut along line and send air mail to save time.

RUSH me, without obligation, latest information on new larger sizes and heavier wall thicknesses of Ohio Welded Steel Tubing.

Name_____ Title_____

Company _____

Address_____ City_____ State_____

CELANESE POLYMER COMPANY

announces a new engineering material

CELCON®

ACETAL COPOLYMER

Celcon is an entirely new Celanese plastic offering advantages over metals and other fabricating materials in many applications. Celcon has a unique combination of properties, including high structural strength over a broad temperature range, excellent moldability, resistance to corrosion and creep, fine color and surface. Best of all, in extensive laboratory and field tests, Celcon performed at a high level with long-range stability. Celcon promises to answer the need for a material in which you can design with greater confidence!

Celanese POLYMER

Product of Radically New Molecular Architecture

Celcon is a result of extensive Celanese experience in polymer chemistry. It makes possible new concepts of material use; it is a new design medium.

Celanese maintains strict control of Celcon production, from raw materials to finished polymer. Celanese is the world's largest producer of trioxane—basic monomer of Celcon production. Celcon is now available for your evaluation in developmental quantities on a restricted basis.

Celcon Meets the Challenge of the Materials Age

- Combines low cost with high strength and rigidity
- Easily fabricated—injection molded, extruded, machined
- Resistant to a wide range of chemicals
- Resistant to high temperatures
- High creep resistance even at elevated temperatures
- Excellent colorability
- Unusual versatility in molding
- Broad molding range

Uses as Varied As Industry Itself

Celcon, as a fabrication material and styling medium offers many advantages over metals and other materials for a wide variety of applications, such as timing gears, door handles, pipe and plumbing, sporting goods, automotive parts, electrical appliance parts, machinery housings and components, pump parts and impellers. But these are only an *indication* of where this versatile new engineering material can be used to both product and cost advantage.

Celanese® Celcon®

For complete details, please write, outlining your application, to:
Celanese Polymer Company, Dept. P102D, 744 Broad Street, Newark 2, N. J.

Celanese Polymer Company is a Division of Celanese Corporation of America

NEW SUPER-TOUGH ORE HAULER USES

N-A-XTRA

HIGH-STRENGTH STEEL TO CUT DEAD WEIGHT AND STRETCH PAYLOAD CAPACITY

This Lectra Haul M-55, made by Unit Rig and Equipment Co. of Tulsa, is now working in the open pit iron mines in Minnesota's Mesabi range. In bone-freezing —40° weather, it can stand up to the shuddering shock of 55 tons of drop-loaded iron ore, climb a 6% grade at 8.6 mph then dump those 55 tons in a crashing, grinding 18 seconds. The quarry body that takes this loading impact and dumping abrasion in sub-zero temperatures is made of N-A-XTRA high-strength steel, with X-A-R Abrasion Resistant Steel for extra hardness and toughness in wear areas. N-A-XTRA also forms the structural members of the complete unit.

Why N-A-XTRA? Because, pound for pound, it's nearly three times stronger than ordinary steel. That means it's strong enough to absorb severe punishment without constant maintenance, and light enough to handle the highest possible payload. In fact, the Lectra Haul payload is almost as much as the net vehicle weight itself.

N-A-XTRA and X-A-R are doing the job where only the strongest steels will do. Easily formed and welded, they are making products stronger, lighter, longer lasting. N-A-XTRA fully quenched and tempered steel is available in four levels of minimum yield strengths, from 80,000 to 110,000 psi. X-A-R steels are supplied in hardnesses from 360 to 400 BHN (or, by agreement, in a range between 265 and 500 Brinell). For full technical information, write Great Lakes Steel Corporation, Product Development, Dept. MDE-1, P.O. Box 7310, Detroit 2, Michigan.

A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan

N-A-XTRA AND X-A-R STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

Benedict-Miller, Inc. Lyndhurst, New Jersey	Joseph Demsey Co. Cleveland, Ohio	Ducommun Metals & Supply Co. Los Angeles, California
Interstate Steel Co. Evanston, Illinois	Lockhart Iron & Steel Co. Pittsburgh, Pennsylvania	Marsh Steel & Aluminum Co. Kansas City, Missouri
O'Neal Steel, Inc. Birmingham, Alabama	Salt Lake Hardware Co. Salt Lake City, Utah	A. C. Leslie & Company, Ltd. Montreal, Canada

Lectra Haul M-55; made by
Unit Rig and Equipment Co., Tulsa, Okla.
224,000 lbs. GVW
110,000 lbs. capacity
700-hp. diesel engine
4 wheel-mounted electric traction motors

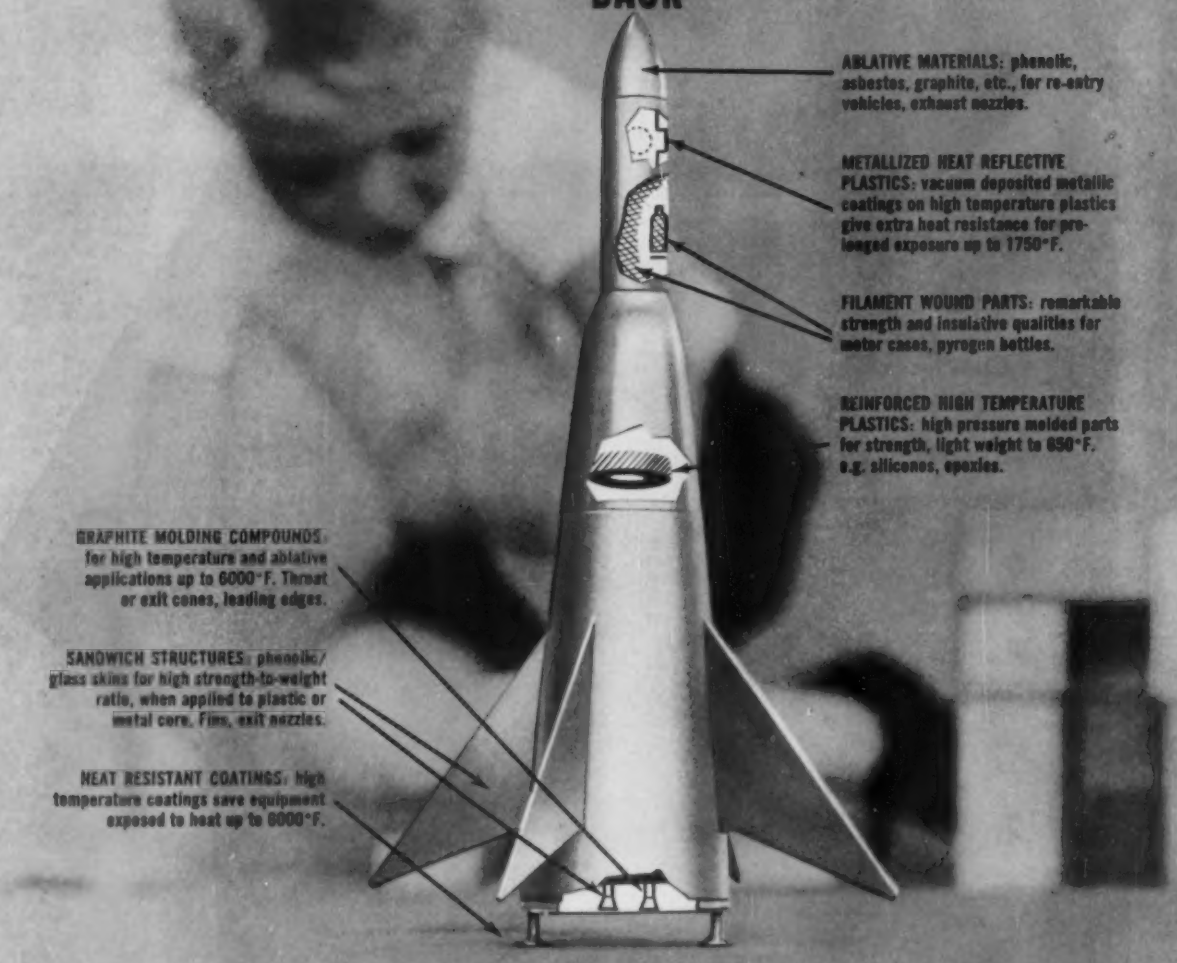
Look for the STEELMARK on the products you buy; place it on the products you sell.

Design note: Bottom, sides and front of the Lectra Haul quarry body were fabricated of N-A-XTRA 100 (100,000 psi minimum yield strength) from plates ½" thick and reinforced with cold-formed channels of ⅜" thick N-A-XTRA 100. Wear areas of bottom, side and front slopes were made of X-A-R Abrasion Resistant Steel from plates ⅜" thick, 388 Brinell hardness. Fabrication followed standard shearing, gas cutting and welding procedures.

***Great Lakes Steel** is a Division of* **NATIONAL STEEL CORPORATION**

For more information, turn to Reader Service card, circle No. 361

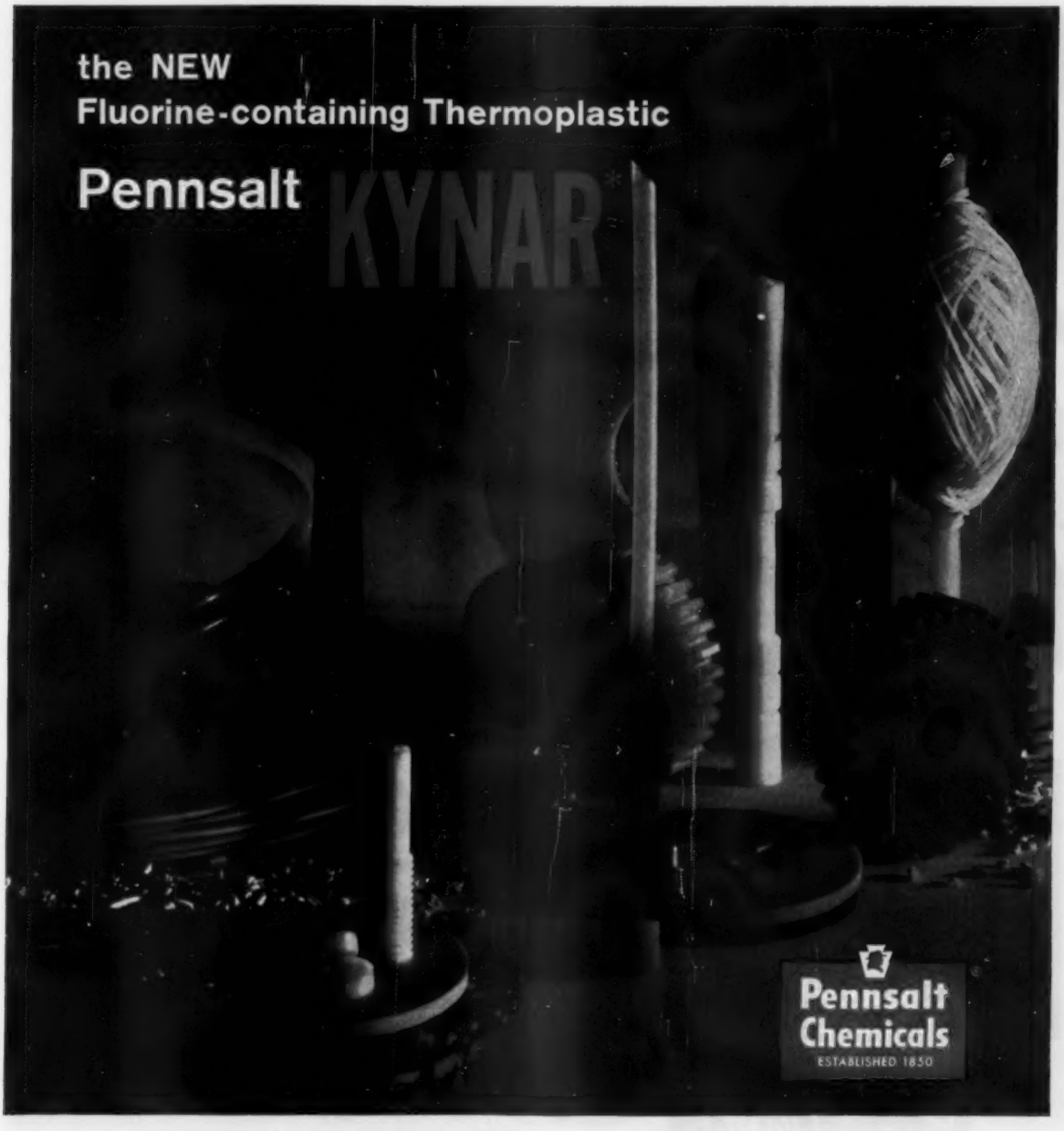
THESE SWEDLOW ADVANCED MATERIALS WILL HELP YOU GET HIM THERE– AND BRING HIM BACK


ABLATIVE MATERIALS: phenolic, asbestos, graphite, etc., for re-entry vehicles, exhaust nozzles.
METALLIZED HEAT REFLECTIVE PLASTICS: vacuum deposited metallic coatings on high temperature plastics give extra heat resistance for prolonged exposure up to 1750°F.
FILAMENT WOUND PARTS: remarkable strength and insulative qualities for motor cases, pyrogen bottles.
REINFORCED HIGH TEMPERATURE PLASTICS: high pressure molded parts for strength, light weight to 650°F. e.g. silicones, epoxies.
GRAPHITE MOLDING COMPOUNDS: for high temperature and ablative applications up to 6000°F. Throat or exit cones, leading edges.
SANDWICH STRUCTURES: phenolic/glass skins for high strength-to-weight ratio, when applied to plastic or metal core. Fins, exit nozzles.
HEAT RESISTANT COATINGS: high temperature coatings save equipment exposed to heat up to 6000°F.

Right now Swedlow is working to solve problems of materials he'll need to travel safely into space. Swedlow leadership in advanced materials and parts is based on the ability to solve today's complex problems of fabrication. Next time you have such a problem, put Swedlow to work on design, development, production. Write for information to Dept. 18

SWEDLOW Inc. LOS ANGELES 22, CALIFORNIA · YOUNGSTOWN 9, OHIO

Swedlow



with a superior combination of key properties...

- **Resistance** to corrosive environment and wide-ranging temperature
- **Strength** under tension, compression, impact
- **Formability** by all standard plastic fabricating methods

and additional benefits...

- Dimensional stability—no cold flow or creep
- Stability to weather and ultra-violet exposure
- Non-flammability

Kynar resin ... first of a series of Pennsalt high-performance plastics ... is a crystalline, high molecular weight polymer of vinylidene fluoride ($CH_2{=}CF_2$). It is now available in commercial quantities ... powder and pellets ... in grades matched to desired fabrication methods and end-product characteristics. For product information, prices, technical assistance or samples, write Research Products Development Dept., PENNSALT CHEMICALS CORPORATION, P.O. Box 4388, Philadelphia 18, Pa.

**KYNAR is a trade-mark of Pennsalt Chemicals Corp.*

For more information, circle No. 386

For more information, turn to Reader Service card, circle No. 338

Lubrication Problem?

TRY *PUREBON!

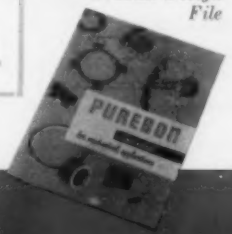
*CARBON-GRAPHITE ESPECIALLY DESIGNED FOR MECHANICAL APPLICATIONS

Where lubrication is a problem on bearings, seals, blades and similar sliding or rotating parts, **PUREBON** is often the ideal solution.

OUTSTANDING PROPERTIES OF PUREBON

1. Self-lubricating
2. Stable at high temperatures
3. Light in weight
4. Moldable to size
5. Low cost, where moldable to size
6. Chemically inert
7. Readily machinable

Request Catalog #60 or see Sweet's Product Design File



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NOW!

READY PACK IN ROLLS...

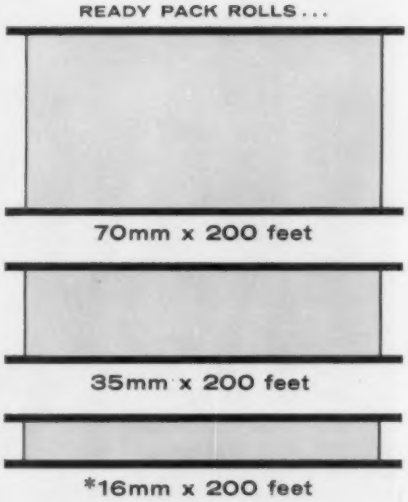
Kodak Industrial X-ray Film, Type AA and Type M in 16mm, 35mm and 70mm widths, 200-foot lengths

Here is America's preferred Industrial X-ray Film in a new convenient form—in 200-foot rolls, and in three widths. Ready Pack rolls are the answer for panoramic or moving slit methods of radiography of thin-wall vessels and pipe, honeycomb, circumferential welds, etc. Unroll the needed film, cut it off, seal the ends with opaque, pressure-sensitive tape. You are ready to inspect aluminum or magnesium alloys, thin steels or anything where lead screens are not required.

Ready Pack rolls are supplied on cardboard cores, 12 inches in diameter. The film is enclosed in a light-tight wrap-around sealed covering, without interleaving paper. It keeps clean and does away with darkroom loading. For processing, just separate the wrap along the sealed edge and remove the film.

For further information or to order a supply, contact your x-ray dealer or write us for a Kodak Technical Representative to call.

READY PACK ROLLS...



*For the present this size available only on a special order basis.

Kodak
TRADEMARK

EASTMAN KODAK COMPANY
X-ray Sales Division, Rochester 4, N.Y.

For more information, turn to Reader Service card, circle No. 349

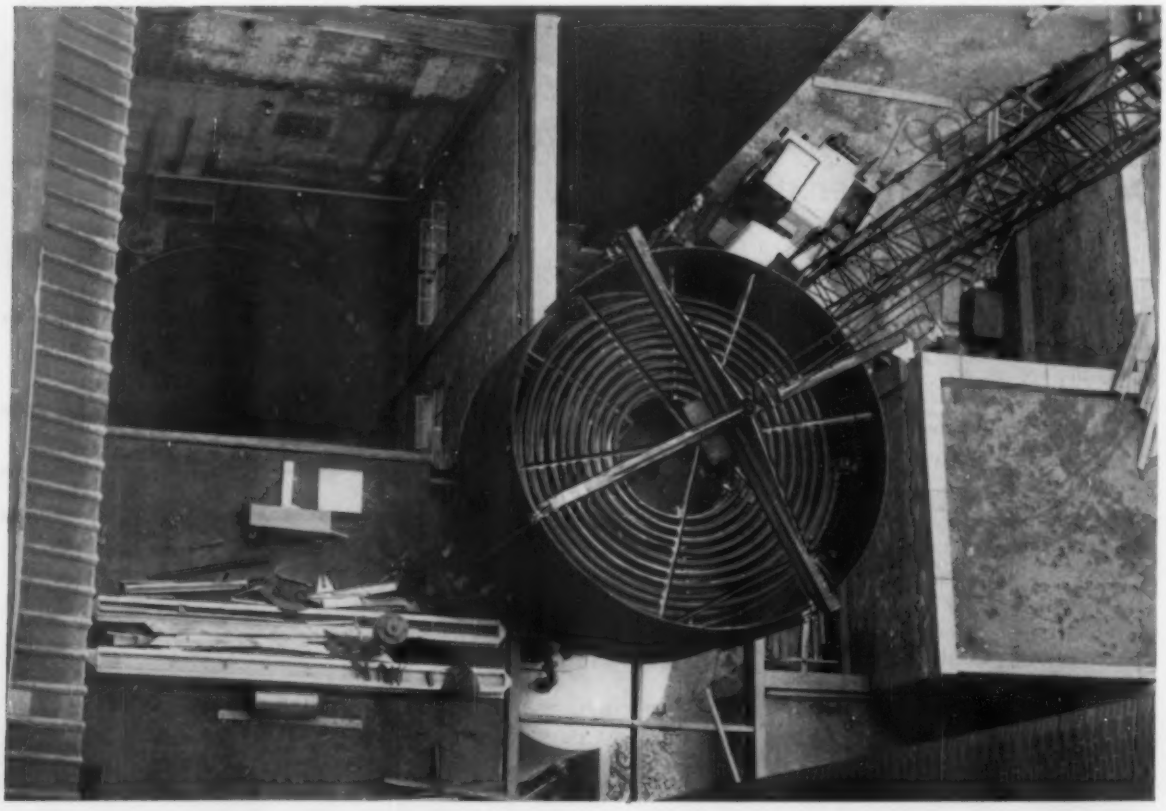
Seagram's "to be sure" for its new

REVERE COPPER
Plate and Tube fabricated by
Matt Corcoran & Company
into whiskey refinement
distillation unit for
Joseph E. Seagram & Sons, Inc.

On these pages, you see what is known in distilling as a "doubler". Doubling is further distillation of beverage spirits in a "doubler" or copper kettle to acquire an additional degree of refinement. Coupled with a larger capacity, this doubler offers a distinct advantage—a larger distillation cycle resulting in a greater uniformity of product. These are some of the reasons for the consistently fine quality of Seagram products.

This doubler was fabricated in three sections which were transported on flat-bed trucks from the copper-smithing plant of Matt Corcoran & Company, Industrial Boulevard in Louisville, Kentucky to the port of shipping at Aurora, Ind. From there, they were trucked to the Joseph E. Seagram & Sons, Inc. Distillery at Lawrenceburg, Indiana.

In order to install the doubler it was necessary to remove the roof from a distillery building. Once in the building, the



used REVERE COPPER "Doubler"...

three sections were welded together, and the roof was replaced.

Revere Copper was selected for the doubler because the inherent characteristics of man's oldest metal have proved superior in distilling fine whiskey. It does not react with alcohol and a wide variety of other liquids and gases.

And, as to the advantages of working with copper, Matt Corcoran & Company, who has been working with this metal for over a half century has this to say, "Copper is extremely easy to work into any desired shape or design, it conducts heat quicker and with greater uniformity than any other commercial metal, and is quickly and economically welded by modern methods. This latter characteristic of copper was particularly important in the Seagram installation. In this case the three-section doubler had to be welded together under conditions where there was barely room for a man to get between the sides of the vessel and the walls of the building in which it was installed."

And, it was because of these same superior characteristics that copper was used in the interior of the doubler in the form of Revere Copper Tube . . . 1,000′ of 4″ O.D.

It is jobs such as this doubler that have given Revere the background of experience that can prove valuable in the solution of your particular metals problem . . . whether it involves copper, brass, aluminum, or any one of their alloys.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

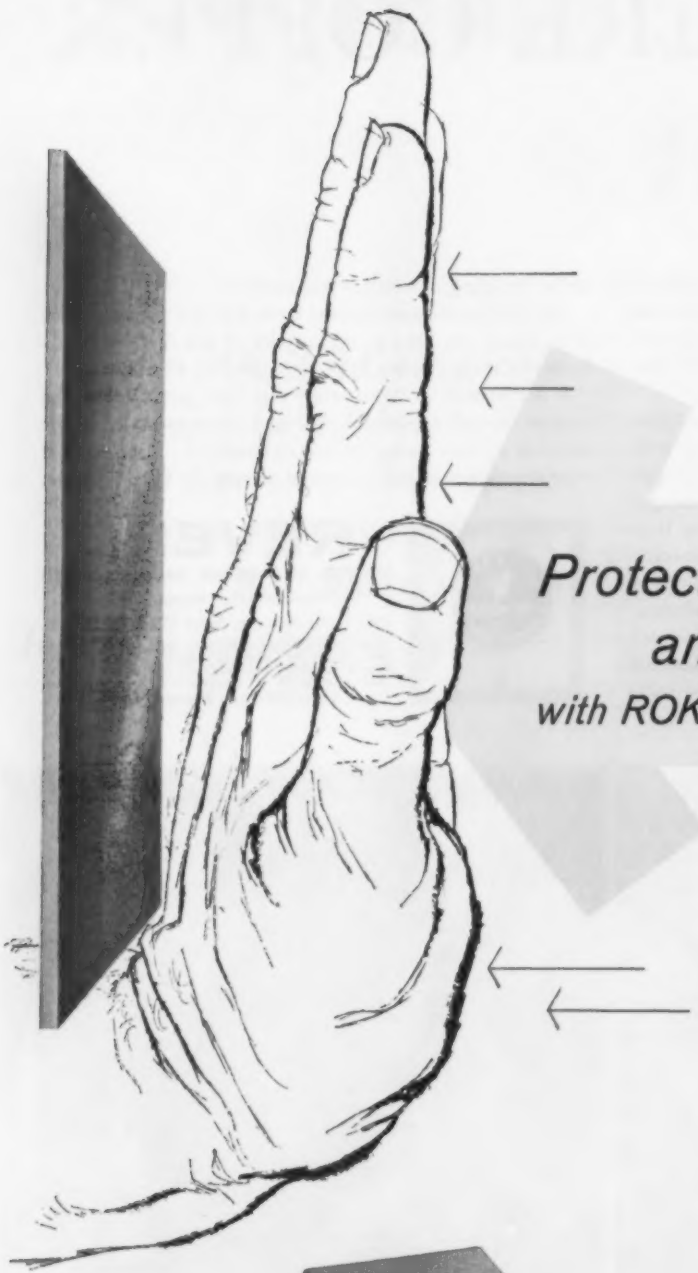
230 Park Avenue, New York 17, N. Y.

Sales Offices in Principal Cities. Mills: Rome, N. Y.; Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford and Plymouth, Mass.; Brooklyn, N. Y.; Newport, Ark.; Ft. Calhoun, Neb.

Distributors Everywhere.

(left)—**LOWERING BOTTOM SECTION** of the doubler into position. (above)—**TOP SECTION OF DOUBLER** is fitted into place. You can readily see why it was necessary to remove roof prior to installation. *(above right)*—**TOP SECTION OF DOUBLER** being removed from flat-bed truck and placed aboard barge preparatory to trip to Aurora, Indiana, from where the three sections were trucked to the Joseph E. Seagram & Sons, Inc., Distillery at Lawrenceburg, Indiana.

For more information, turn to Reader Service card, circle No. 372



Here's the fast, economical way to protect vital parts and equipment against temperatures up to 4600°F . . . extreme abrasion . . . electrical energy . . . erosion and corrosion. Simply apply ROKIDE Ceramic Coatings — hard, crystalline refractory materials — which provide *positive* protection.

ROKIDE Coatings are supplied in rod form as "Z" Zirconium Oxide, "A" Aluminum Oxide, "C" Chrome Oxide, "ZS" Zirconium Silicate, and "MA" Magnesium Aluminate. To apply, rod is heated and the molten particles projected at high velocity against the prepared surface, where they adhere and solidify.

ROKIDE Coatings are extensively used for both military and industrial applications such as: missile components, bearing surfaces, extrusion dies, furnace and feed rolls, induction coils, igniter tips, strain gages, buffing fixtures, mechanical seal rings, pump shafts, capstan wheels, impellers, crucibles, etc.

Protect modern metals and materials

with ROKIDE Ceramic Coatings*

ROKIDE Coatings are available from a number of strategically located job shop applicators or direct from Norton Company, Worcester, Mass., and Santa Clara, California. Find out how they can cut *your* maintenance and production costs. NORTON COMPANY, 343 New Bond Street, Worcester 6, Massachusetts.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

Write for full details on the ROKIDE Coating Process.

NORTON
REFRACTORIES
Engineered . . . Rx . . . Prescribed

75 years of . . . Making better products . . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — BEHR-MANNING DIVISION: Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

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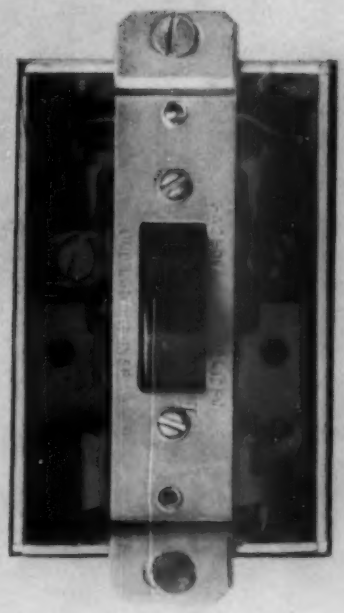
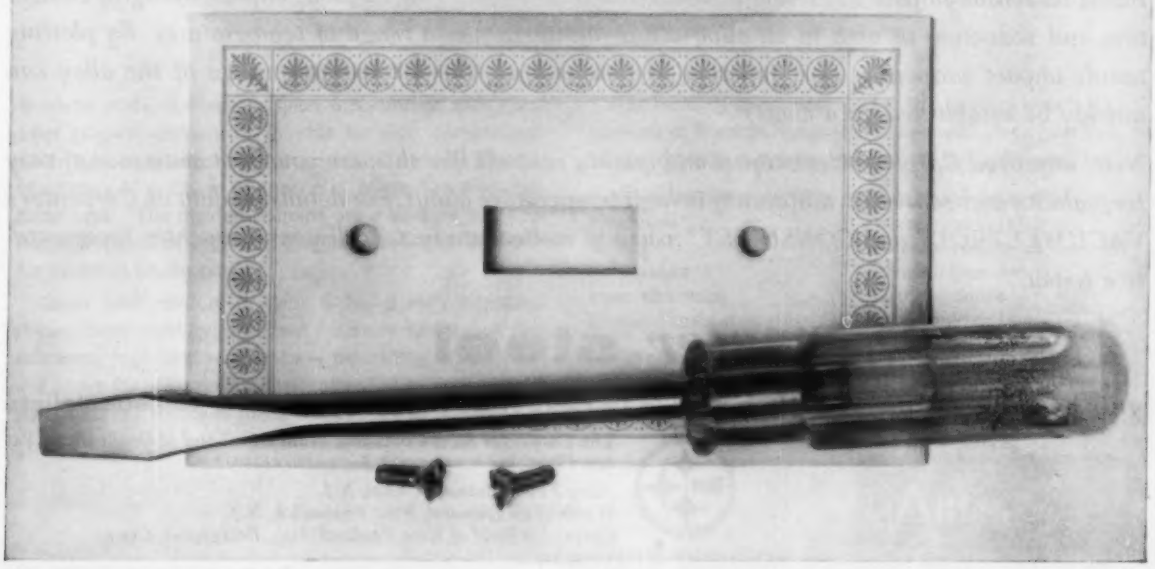


The switch is to decorated Beetle® Urea Plastic.

Now you can mold multi-colored decorations into switch plates, stove hardware, business machine keys, temperature indicator knobs, electrical appliance housings, and countless other products—and maintain production economy! By incorporating a patterned, resin-impregnated foil during the molding process, you avoid costly after-decoration. The pattern becomes part of the molded Beetle Urea plastic. It won't chip off, scratch off or wear off. And you still enjoy these proven Beetle plastic advantages: resistance to detergents, oils and grease; arc-resistance; track-resistance; good dielectric strength; surface hardness; stain resistance; wear-resistance; unlimited range of colors. Write for complete information or call your local Cyanamid representative.

AMERICAN CYANAMID COMPANY CYANAMID PLASTICS AND RESINS DIVISION

Wallingford, Connecticut. Offices in: Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Detroit • Los Angeles • Minneapolis • New York • Oakland • Philadelphia • St. Louis • Seattle • In Canada: CYANAMID OF CANADA LIMITED, Montreal • Toronto



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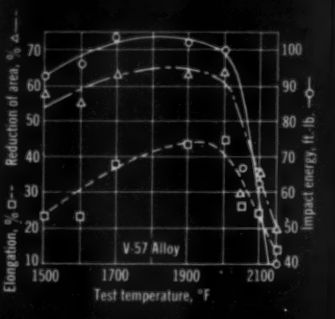


Plot of tensile-impact properties indicates that the recommended hot working range of Carpenter's V-57 alloy in wrought form lies between 1700 and 2000°F.

fast, new test pinpoints best forging range for high temperature alloys

A fast, easy and economical, new Carpenter test takes much of the guesswork out of hot working high temperature alloys. The results, when correlated with other Carpenter test data and mill experience, reveal the best working temperatures—help forge shops get better finishes with less machine clean-up . . . less wasted steel . . . fewer rejects . . . faster fabricating.

Based on tensile-impact . . . Using a modified tensile-impact test method, impact strength, elongation and reduction of area in an alloy are determined over a range of temperatures. By plotting tensile-impact properties as a function of temperature, the hot working range of the alloy can quickly be established. (see chart)

New, improved Carpenter techniques and quality controls like this, are your best assurance of easy forgeability and consistent uniformity in high temperature alloys. For details, or data on Carpenter's VACUMELTROL® and CONSUMET® vacuum melted products, call your Carpenter representative today.

Carpenter steel

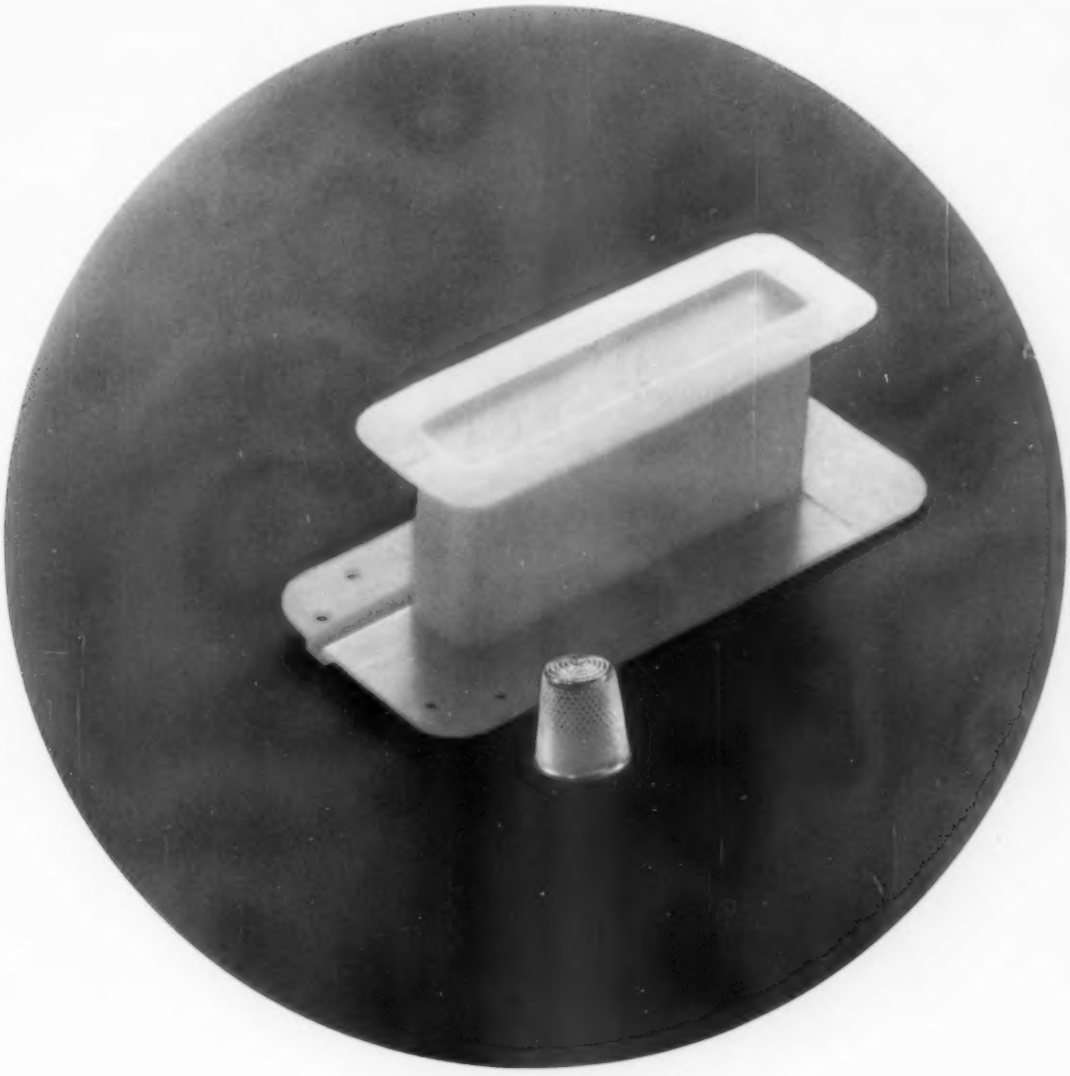
you can do it ***consistently*** better with Carpenter Specialty Steels for specialists

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Export Dept., Port Washington, N.Y.—"CARSTEELCO"
Alloy Tube Division, Union, N.J.
Webb Wire Division, New Brunswick, N.J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

For more information, turn to Reader Service card, circle No. 375

For more information, circle No. 416

Plaskon NYLON 6, GLASS-FILLED, TAKES HEAT, STRESS



Bobbins made of Plaskon Nylon 6 reinforced with glass fiber (shown above with thimble for size comparison) contribute to a better exciter generator, reports Electric Machinery Mfg. Co. of Minneapolis, Minn. The manufacturer says: "The molded bobbins are a **durable** and **economical** means of providing the field winding in one unit for insertion on the pole."

Glass fiber reinforced Nylon 6 has greatly improved dimensional stability, excellent moisture resistance and extremely high heat resistance — permitting intermittent use above 400 degrees F. Tensile strength is high (30,000 psi), as is resistance to distortion caused by winding.

The molding compound used in this bobbin, Nylafil G3, consists of Plaskon Nylon formulated with glass filler in a rigidly controlled process by Fiberfil, Inc., Warsaw, Ind.

PLASKON NYLON 6 OFFERS:	
toughness	easier colorability
rigidity	moisture resistance
light weight	abrasion resistance
lower shrinkage	corrosion resistance
greater impact strength	heat resistance
	lower molding temperatures

Take advantage of these hard-working properties for your product—specify Plaskon Nylon. Write now for technical data on Plaskon Nylon and Nylafil G3.

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

BASIC TO AMERICA'S PROGRESS

Plaskon WOOD-FLOUR FILLED UREA...EFFICIENT

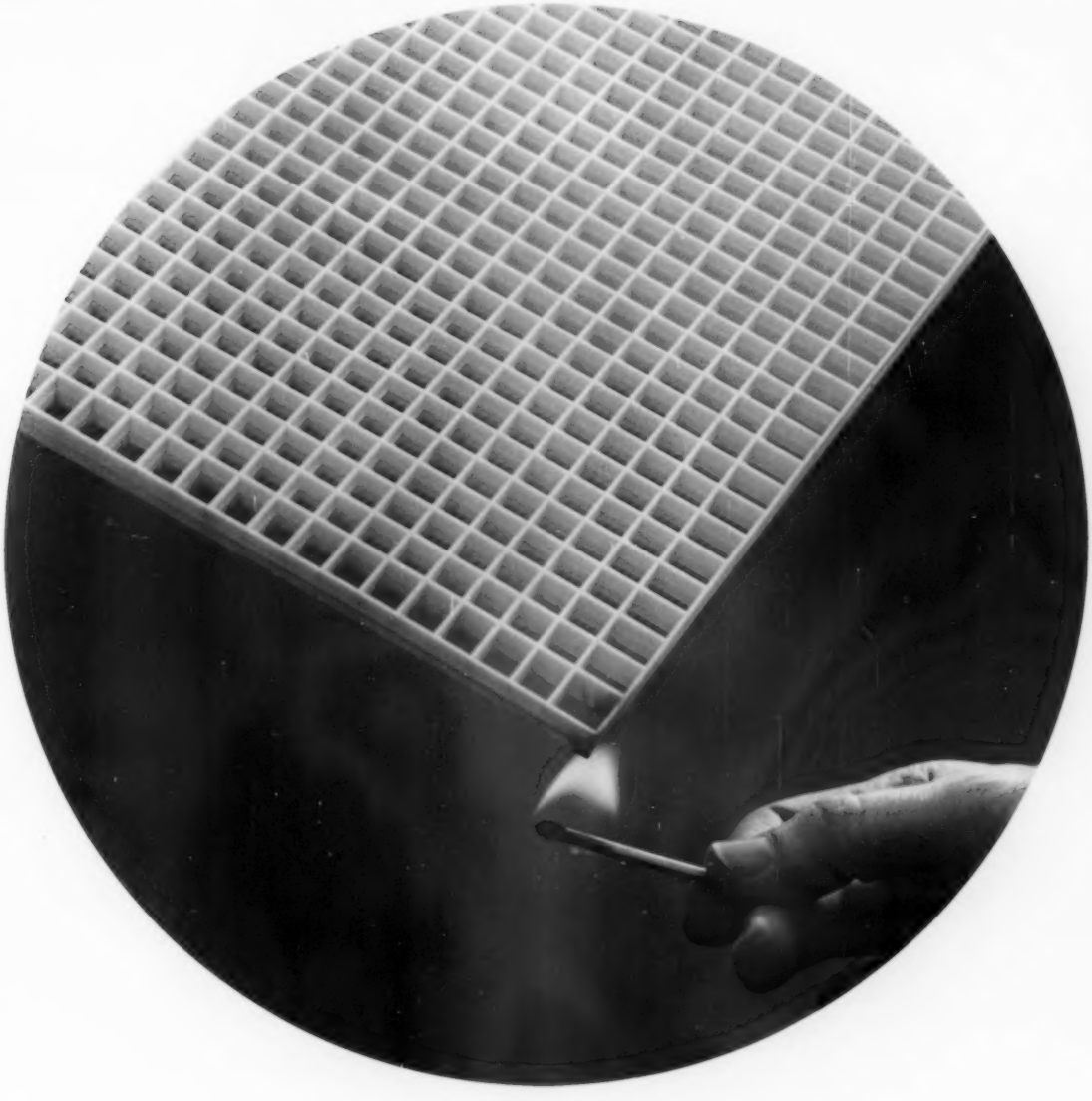
Efficient both electrically and economically, this Plaskon Wood-Flour Filled Urea circuit breaker case delivers superior arc resistance . . . 80-100 seconds (ASTM). The maker states that its dielectric and insulating properties have proven satisfactory in this circuit breaker case, as well as other cases in his line.

Allied Chemical Corporation developed this material specifically for high-speed automatic molding of electrical parts; Plaskon Wood-Flour Filled Urea is now thoroughly proven in the field. It matches or exceeds the more expensive alpha-cellulose urea in all properties except translucency and color range. Available in NEMA brown or standard black.

Other important properties of Plaskon Wood-Flour Filled Urea: Superior color-fastness • Impervious to household solvents • Non-electrostatic surface.

You may well profit by switching to Plaskon Wood-Filled Urea . . . write us for more information and for samples.

FIRE-RESISTANT UREA . . . NON-STATIC, TOO



Lighting grids like this made of Plaskon Fire-Resistant Urea UFR-28 stand up well to flame!

Where the UL fire tunnel test may cause other white and pastel materials to blister, drip or contribute readily to flame spread, this grid has a low UL flame spread rating of 25 . . . considered "Non-Combustible" in general practice! In addition, its ASTM rating is "Non-Burning."

Called "N. C. Gratelite" by maker Edwin F. Guth Co., St. Louis 3, Mo., this new grid eliminates static electricity charges, too . . . doesn't attract dust.

Other important properties of Plaskon Fire-Resistant Urea UFR-28 . . . high dielectric strength; rigid enough to support itself; hard surface resists scratching and abrasion and facilitates cleanup; colors are spectro-photometrically controlled for precise lighting values.

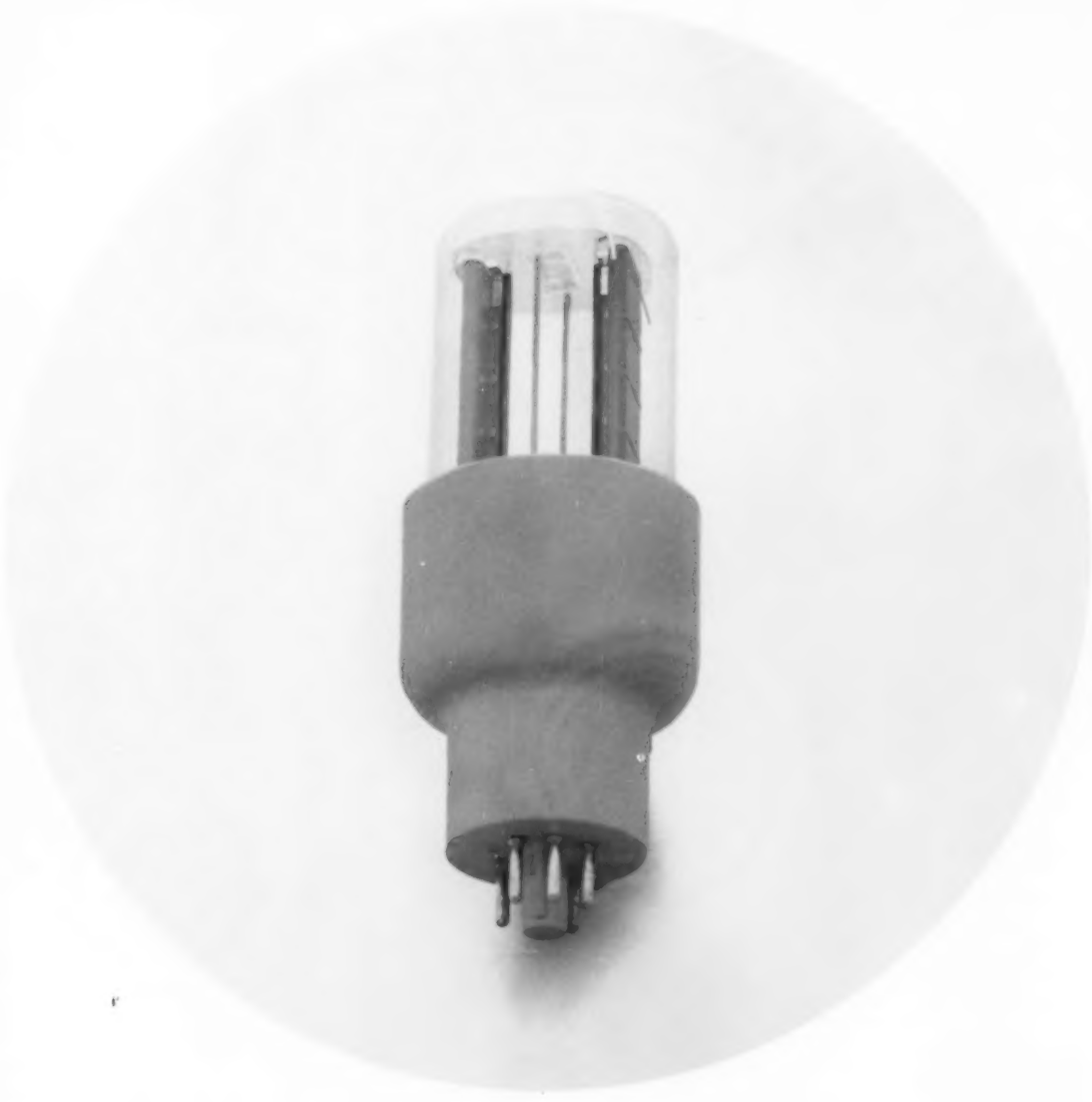
Look to Allied for Urea Molding Compounds when you need good fire resistant and electrical properties, rigidity, strength, wide color range, or combinations of these. Plaskon materials and know-how to help solve your problems are freely available. We'd like to hear from you.

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

BASIC TO AMERICA'S PROGRESS

Plaskon® ALKYDS PROVIDE HIGHEST ARC RESISTANCE



The base of this rectifier tube is made of Plaskon Alkyd Molding Compound. The tube's maker, Chatham Electronics, Division of Tung Sol Electric, Inc., states that . . .

1. Plaskon Alkyds provide high arc and insulation resistance. A three kilovolt potential between base pins presented no problem.
2. The high mechanical shock resistance of Plaskon Alkyd helps this tube to withstand 900 G's, as required by military specification.
3. In this application, a maximum bulb temperature of 250° C (482° F) has no adverse effect on the Plaskon Alkyd base.
4. The fast cure rate, dimensional stability and uniformity of Plaskon Alkyd permit high-speed, high-precision parts production.

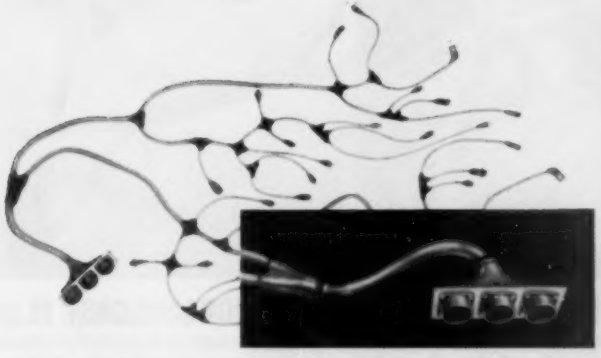
Plaskon Alkyd Molding Compounds are available in three forms . . . free-flowing granular for high-speed automatic molding; glass-reinforced impact grades combining excellent mechanical and electrical properties; putty types for encapsulation. For more about Plaskon Alkyd Molding Compounds, write or call our Alkyd sales department.

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

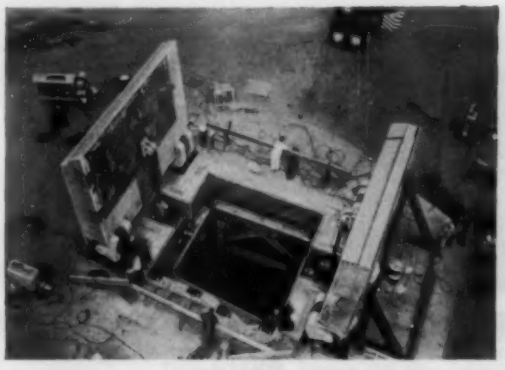
Allied Chemical

General Electric Silicone Rubber helps get Titan ICBM combat-ready

Missile and ground-support applications are "naturals" for the unique qualities of silicone rubber—heat resistance above 600°F, low-temperature flexibility to −150°F, good thermal conductivity, unexcelled ozone resistance and virtually unlimited life under normal conditions. Because it retains its excellent electrical properties over a wide temperature range, G-E silicone rubber is also used for missile wire and cable insulation. Even when continuously exposed to direct flame, it forms a non-conducting ash which gives off no toxic fumes.



Missile wiring harness—General Electric silicone rubber was chosen by Aerojet-General Corp. for the Titan's propulsion system wiring harness. Breakouts and junctions are molded from G-E RTV (room temperature vulcanizing) silicone rubber; wiring is silicone insulated; jacketing is high-strength G-E silicone rubber. Inset shows silicone rubber inserts in connectors. RTV is used in other missiles as a shock-absorbing encapsulant and potting material for electronic assemblies.



200 tons of steel and concrete—Titan missile silo doors by American Machine & Foundry Co. use seals of G-E silicone rubber. AMF also used G-E silicone rubber door seals on the Titan's ground support entry portals and radar silos. Silicone rubber can withstand the heat of rocket blast-off or possible atomic attack while remaining stable in storage for long periods.

Write for more information on G-E silicone rubber, briefly describing your application. Section B434, Silicone Products Department, Waterford, New York.

GENERAL ELECTRIC

◀ For more information, circle No. 416

▲ For more information, turn to Reader Service card, circle No. 382

Look what you can do with Geon

DIP IT. The maker of this water demineralizer did—discovered a low cost, simple way of getting a thick, tough, abrasion-resistant shell that is not affected by the acids and alkalies encountered in water treatment. Geon vinyl coatings can be applied many ways to many products—metals, textiles, papers, and others.

EXTRUDE IT. To obtain a wide variety of shapes and sizes with exceptional accuracy of detail, and exceptional properties. Corrosion-resistant. Abrasion-resistant. Colorful. Geon vinyl is ideal for molding, seals, tracks — comes in rigid form with spring-back properties or in softer form for sealing qualities.

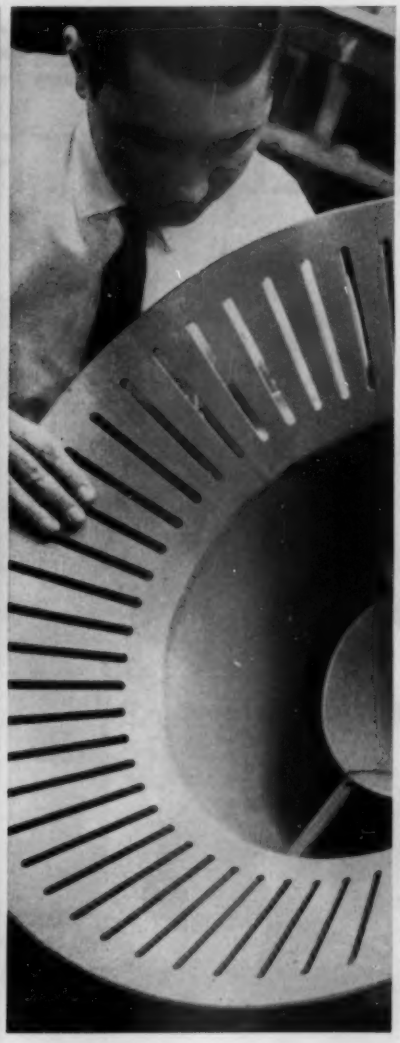
ROTATIONALLY CAST IT. This horse is rotationally cast of Geon vinyl in one piece. Provides the right combination of durometer hardness, tensile strength, heat stability and low viscosity range. Best of all, use of Geon permits exceptional accuracy of detail and color, for true-to-life appearance.

FOR MORE INFORMATION ABOUT THESE and other ways you can use Geon vinyl to improve your product, or open new markets, write Dept. NN-2, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

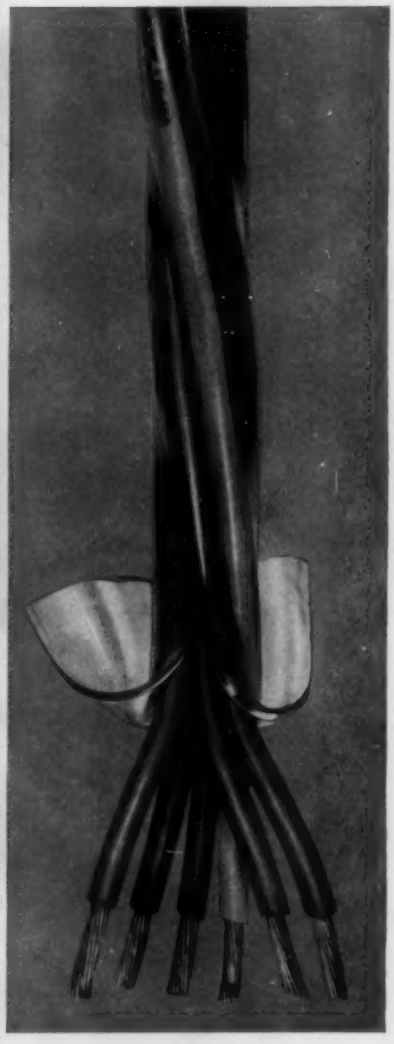
to improve a product

B.F.Goodrich

USE IT IN FOAM FORM. The outside of this "doughnut" is rotationally cast of Geon vinyl to provide a tough, durable skin. Then vinyl foam is injected into the interior cavity to make this part with ideal resilience for sound and vibration dampening.



FABRICATE IT. Sheet of rigid Geon vinyl is easily fabricated into ductwork or—shown here—fume diffusers like this one used for a chemical plant's exhaust system. Rigid Geon vinyl sheet can be machined: the tolerances on the slots shown here are .003". Makes outstanding lightweight corrosion resistant pipe, too.



OR FOR JACKETING AND INSULATION. Here's the new look in truck trailer wire—wires are insulated with colorful Geon vinyl, then the outside jacket is made of clear Geon, so that installers can readily see which wire to connect. Geon offers exceptional electrical properties—as well as outstanding abrasion-and-corrosion-resistance, and good resistance to weathering and heat.

B.F.Goodrich Chemical
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Geon VINYLS

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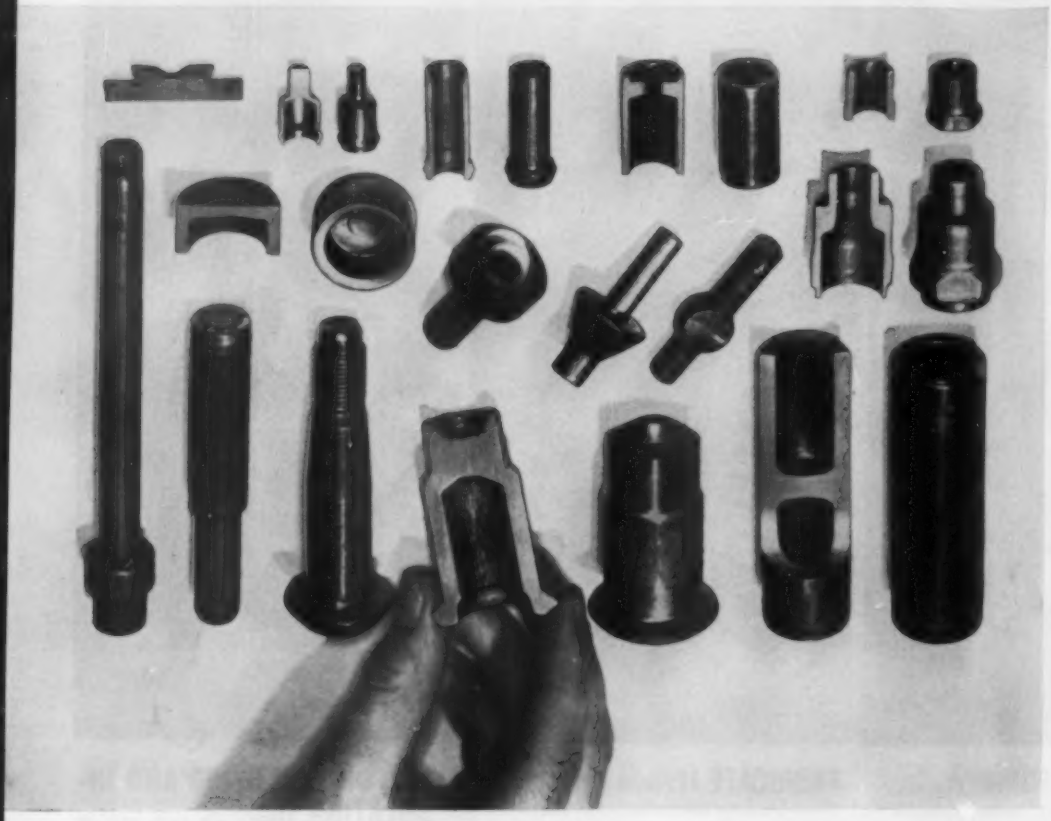
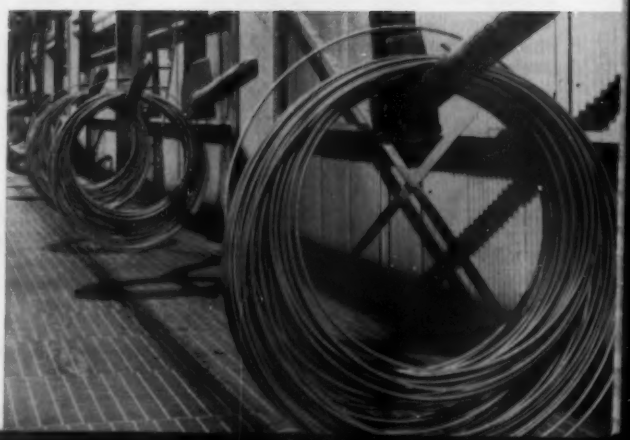
From the industry's most advanced bar mill...

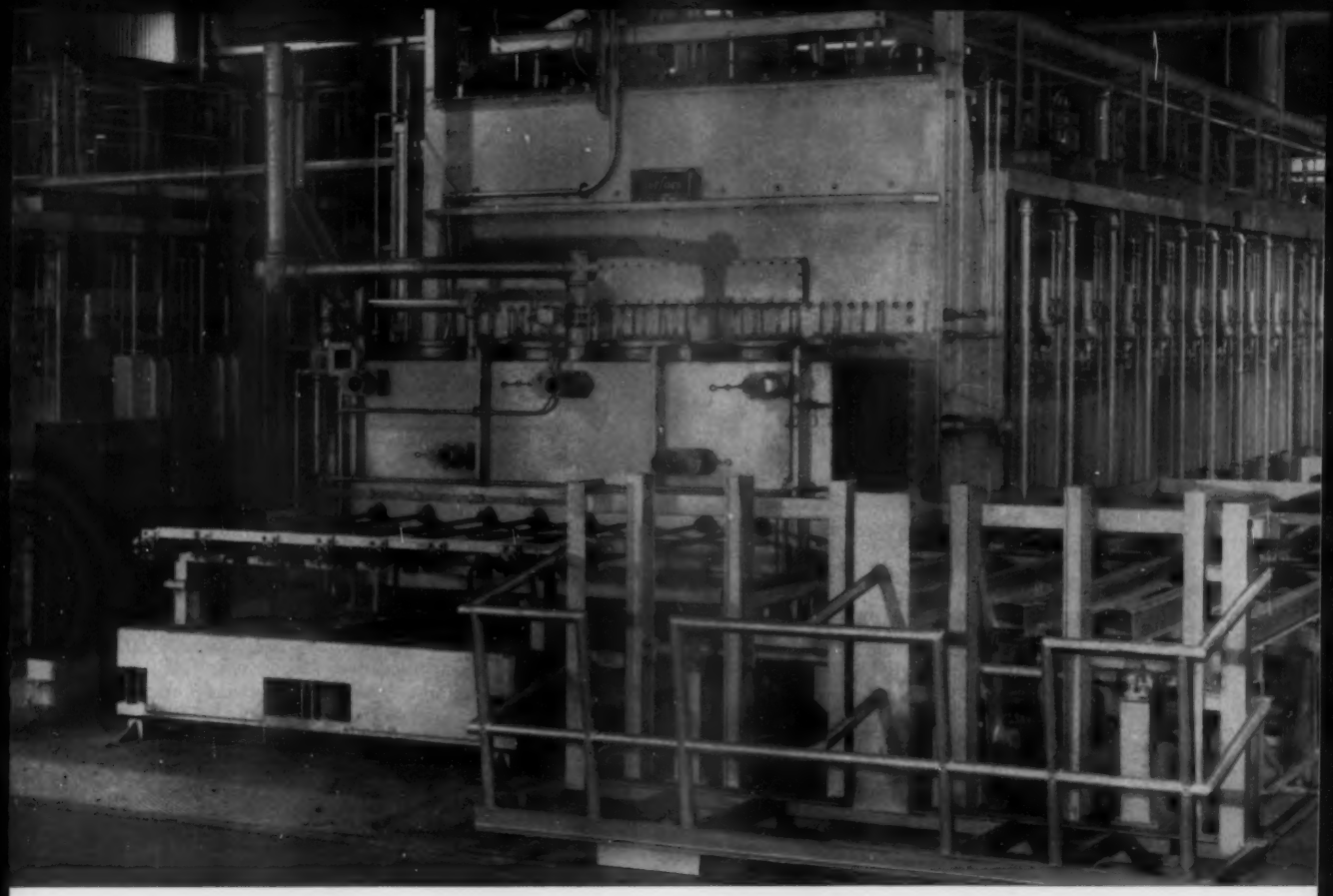
REPUBLIC STEEL FOR COLD EXTRUSION



THE COLD EXTRUSION PROCESS virtually eliminates raw material waste. Standard equipment is available so that retooling costs are not excessive. Bars produced on this 11″ mill have denser, more uniform structures because they undergo more hot work. A larger than usual billet—3″ or 4″ square—is rolled to finished products of standard sizes.

HEAVIER COILS weighing up to 1600 pounds mean fewer fabrication changeovers, less scrap loss. High speed coilers handle the complete range of bars produced (⅜″ to $^{29}/_{64}$″—700 to 900 pounds; ⅜″ to 1½″—1400 to 1600 pounds). Each coil undergoes ultra-precise inspection to assure conformance to specifications, then is double banded for safe, efficient handling.





Annealed, normalized, or spheroidized to your precise specifications

Atmosphere controlled, continuous annealing furnaces give Republic's new 11″ bar mill maximum annealing capacity. Steel for cold extrusion or cold heading can be furnace-treated, finished, and delivered to your precise specifications. The mill has facilities to pickle, oil, lime, or phosphate coat.

Depending on the nature of your product, you may find it more advantageous to use steel in the cold finished form. Either way, our metallurgists will help you select and apply the most economical bar product—carbon, alloy, or stainless—capable of meeting your requirements.

Republic Steel is the nation's largest producer of steel for cold extrusion. For complete data, contact your nearest Republic representative or mail the coupon below. Please indicate if you would like a metallurgist to call.

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- ☐ Steel for cold forging
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Name_____ Title_____

Company_____

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City_____ Zone____ State_____

PROBLEM: DIMENSIONAL STABILITY, *plus good looks and toughness*

The spare tire cover of Ford Motor Company's "Comet" and "Falcon" station wagons is designed to be an integral, though removable, part of the interior body and decor. Thus, excellent dimensional stability is needed to avoid shrinking and warping despite rough handling or changing seasonal temperatures.

Extruded sheets made from BAKELITE Brand high-density polyethylene and vacuum-formed to exact dimensions were chosen for this application. In addition to stability and ease of fabrication, BAKELITE high-density polyethylene is light in weight, with excellent rigidity, toughness, heat resistance and stress-cracking resistance. And, it is available in a wide range of colors. Remember, too: there's variety in BAKELITE polyethylene—with low-, medium-, and high-density formulations. You can use our broad experience to find out which meets your needs best.

EXTRUDED PLASTICS FOR

PROBLEM: IMPACT STRENGTH, *with acid, alkali and heat resistance*

Lightweight, one-piece, dual-compartment sink trays vacuum-formed from BAKELITE high-impact styrene offer housewives and photo developers the convenience of two identical basins in a single sink area. Available in white and colors, the trays are easy to keep clean and withstand bleaches, common acids, detergents and photo developing solutions. Weighing only 1½ lbs., the tray is marketable at a low unit cost.

The manufacturer of this patented dual sink insert, Goodhousewares Products Company, Los Angeles, Calif., chose extruded sheets of BAKELITE high-impact styrene only after other plastics were tested and failed to withstand "daily-use" tests.

PROBLEM: WATERTIGHT JOINTS
that are flexible

The tough flexible waterstop extruded from a BAKELITE Brand elastomeric vinyl plastic compound stops moisture penetration through the joints in concrete walls and floors in the new buildings at International (Idlewild) Airport, N. Y., N. Y. This multiple ridge waterstop or joint membrane is inserted in the construction forms prior to pouring as a joint barrier. The lifetime flexibility of BAKELITE vinyl virtually assures against leakage due to fatigue, breakage, oxidation or chemical deterioration. Electrovert Inc. manufacturers of this "Durajoint" waterstop pioneered this application of plasticized vinyl. They have always specified BAKELITE Brand vinyls for all waterstop extrusions.

SOLVING DESIGN PROBLEMS

Here's how other design engineers used them to solve problems of cost and performance

Take a look at the various products pictured here... study the design problems of each ...see how all were effectively solved. Do you find some similarity between these and your own design problem?

A particular BAKELITE Brand resin may be just the plastic you need. You have a wide range of choice – polyethylenes, epoxies, phenolics, styrenes, vinyls – all of traditionally high UNION CARBIDE quality. See your Sweet's Product Design File, Section 2a/ui, for properties. Or, for more detailed information, just mail the coupon.

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Please send me information on BAKELITE resins and suggested applications. I am especially interested in

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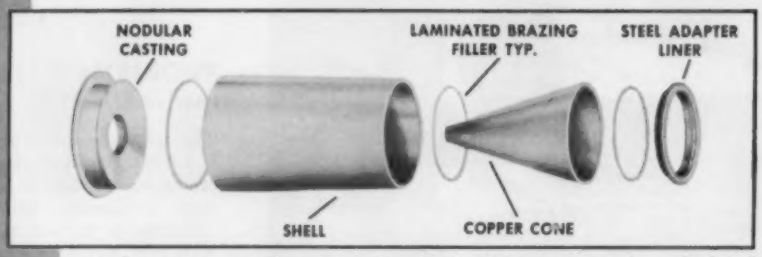

The four components of the nose assembly—nodular iron casting; low-carbon welded steel canister which measures 34" long, 15½" diameter at one end and 17¾" at the other; spun copper cone and low-carbon steel ring. The thinner rings are Easy-Flo 45 wire braided for precise alloy position and control.

Martin Develops New Induction Heating Methods to Braze Lacrosse Missile Assembly With EASY-FLO 45

One of the largest assemblies yet brazed by induction-heating techniques is a section of the Lacrosse missile being manufactured at The Martin Company's Baltimore Division. During development, one problem was posed by the variety of metals used. First it was necessary to braze a low-carbon welded steel canister and nodular iron casting. Then, to complete the assembly, a spun copper cone and low-carbon steel ring were joined to the canister. An induction coil was designed by Martin to accomplish this critical operation. Temperatures had to be restricted between 1300 and 1350°F to prevent a transformation change to the crystalline structure of the nodular iron. Martin's Materials Engineering Laboratory made careful examinations of this assembly and found that Handy & Harman Easy-Flo 45 Silver Brazing Alloy and B-1 Flux make possible the strong, uniform joints necessary to meet the stringent requirements the Company has set. Its low-working temp rature, high strength, fast penetration and flow characteristics are only a few of the features which make this brazing alloy ideal.

More and more aircraft and missile components are being made with the aid of Handy & Harman silver brazing alloys and flux. The products described here are just two of the many available to help solve your problems...make your job easier and quicker. For a more complete picture of silver brazing and the advantages it offers you, write for your free copy of Bulletin 20.

Your No. 1 Source of Supply and Authority on Brazing Alloys

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For more information, turn to Reader Service card, circle No. 407

The first continuously operating optical maser uses a helium and neon gas mixture for its active medium. The maser, essentially a light amplifier, offers a means of transmitting vast amounts of information by modulating a continuous beam of coherent (single frequency) light. Like previous masers, which use crystals to produce brief signals, the new instrument promises to be an excellent device for precise distance measurements and for studying atomic structure.
Source: Bell Telephone Laboratories, 463 West St., New York 14.

Oxidation resistance of zirconium and tantalum can be increased 20-30 times by boriding, according to recent Russian research. Thin coatings, 0.008-0.017 in. thick, on these metals are said to have a Vickers hardness of 1300-2000 and a microhardness of 2300-2900 and above. Borided tungsten, molybdenum and columbium are claimed to have wear resistance several dozen times higher than that of case-hardened steel. The refractory metals are borided in molten borax-boron carbide baths or by using boron and boron carbide powders in a vacuum furnace.
Source: *Review of the Soviet Technical Press*, Oct 21, '60, Office of Technical Services, Washington 25, D. C.

Use of reinforced plastics for certain jet engine parts has improved engine performance and halved the production cost of the parts, according to a recent report. The experimental engine's gas turbine compressor housing is made of glass-reinforced phenolic and polyester instead of magnesium or aluminum alloys. Other advantages: greater corrosion resistance and reduced weight.
Source: Materials Engineering Depts., Westinghouse Electric Corp., Box 2278, Pittsburgh 30.

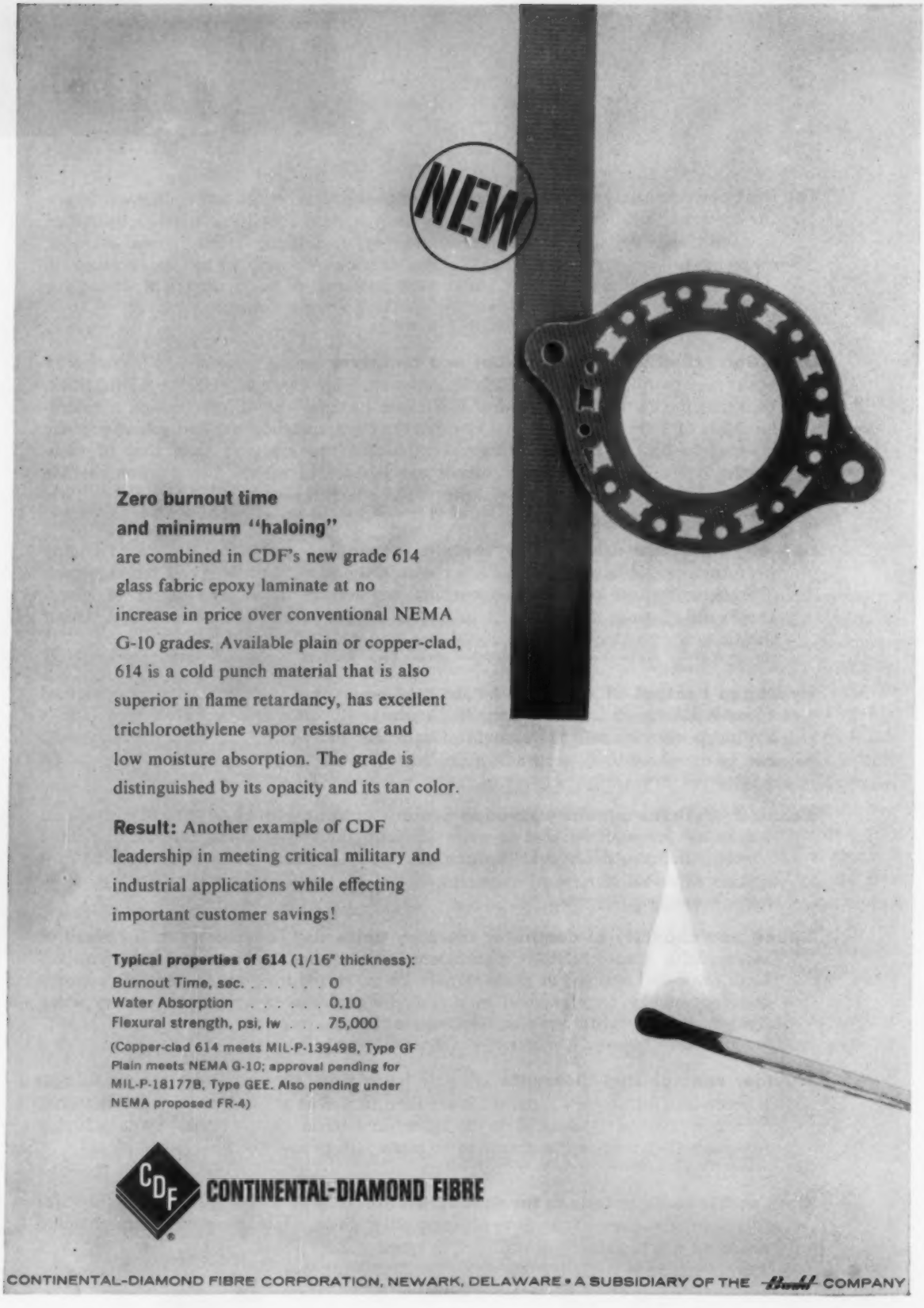
Hydrogen content of steel can be accurately measured in only 15 min by a method recently developed in Great Britain. Argon is passed over a hot steel sample to a hydrogen-sensitive cell. The amount of hydrogen picked up from the steel reportedly can be measured to an accuracy of one part per million.
Source: British Welding Research Assn., British Information Services, 45 Rockefeller Plaza, New York 20.

Foamed urethane plastic extruded around copper piping is said to provide an insulating preassembly that is more efficient, more economical and smaller than conventional pipe coverings. The urethane coating is four times as efficient as cork and six times as effective as magnesia.
Source: Quantum, Inc., Wallingford, Conn.

Speed and capacity of computer memory units may be increased as the result of studies of a photoconductive phenomena called "persistent internal polarization." Data presented by light or radio signals can be stored invisibly in films of cadmium and zinc sulfides until exposed by a second signal. An experimental memory using light flashes is said to write or read in less than 1 μsec.
Source: New York University, Washington Square Center, New York 3.

Nuclear reactor fuel elements are now being made by vibrating uranium dioxide powder into thin hollow rods which are then forged or swaged, to the final diameter. The new method is claimed to be more economical than present manufacturing processes that require the urania to be made into precise pellets.
Source: Babcock & Wilcox Co., 161 E. 42 St., New York.

Collapsible radio antennas for spacecraft are being developed using Mylar polyester film and aluminum foil. Stowed compactly during launching, the experimental antennas will be inflated or unfurled in space.
Source: Missile and Space Div., Lockheed Aircraft Corp., Sunnyvale, Calif.



Zero burnout time
and minimum "haloing"
are combined in CDF's new grade 614 glass fabric epoxy laminate at no increase in price over conventional NEMA G-10 grades. Available plain or copper-clad, 614 is a cold punch material that is also superior in flame retardancy, has excellent trichloroethylene vapor resistance and low moisture absorption. The grade is distinguished by its opacity and its tan color.

Result: Another example of CDF leadership in meeting critical military and industrial applications while effecting important customer savings!

Typical properties of 614 (1/16" thickness):

Burnout Time, sec.	0
Water Absorption	0.10
Flexural strength, psi, lw	75,000

(Copper-clad 614 meets MIL-P-13949B, Type GF Plain meets NEMA G-10; approval pending for MIL-P-18177B, Type GEE. Also pending under NEMA proposed FR-4)

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Today's Five Trends in

Powder Metallurgy

by Donald Peckner, *Associate Editor, Materials in Design Engineering*

Timed to coincide with the annual meeting of the metal powder industry, here is a quick survey of . . . Prealloyed powders • Coated powders • Large parts • Composite structures • Magnetic alloys

■ Powder metallurgy — in research, design, materials and products—long ago left the back alley, pill press status it originally held. The first fascination with the ability to turn out a myriad of inexpensive small parts of relatively simple shape has settled down to the serious application of metal powders to jobs that were not considered commercially feasible five years ago.

Currently, the interest of engineers and designers is focused on several trends. Prealloyed powders, available for a number of years, are coming into wider use because of the increased need for highly alloyed materials. Coated powders, likewise producible for many years, are arousing interest as possible money-savers where high corrosion resistance is needed. Larger parts can be specified with confidence today since many parts manufacturers have installed presses capable of producing them. Stronger parts seem likely in the near future as the result of experiments in reinforcing metal powder parts with metal fibers. And a wide range of alloys has become available for magnetic cores made by powder metallurgy.

Some of these trends are still in infancy; some are now becoming of significant proportions. They will be among the leading topics of discussion at the 17th annual meeting of the Metal Powder Industries Federation this month. Let's take a brief look at each.

Purolator Products Co.

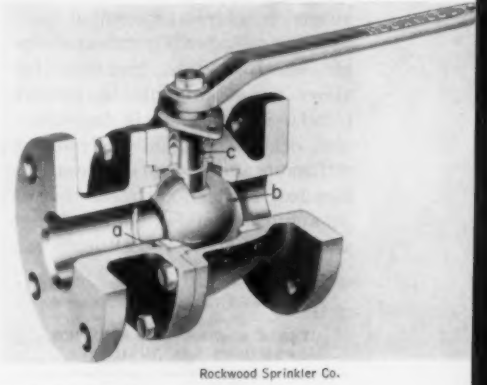
Filter element *of stainless steel, supported by a metal edge base, operates under 150 psi pressure, handles 200 gpm of liquid nitrogen at —325 F.*

1. Prealloyed powders

Why specify a prealloyed powder when a blended composition is usually not as expensive? As the technology of powder metal-

Keystone Carbon Co.

Collection of gears *made from AISI 4630 alloy steel powder. Largest gear is 4.5 in. in dia.*

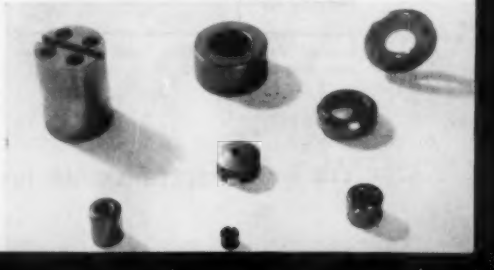


Rockwood Sprinkler Co.

Stainless ball valve, *built for use in corrosive solutions, has three type 316 prealloyed powder components: (a) rings, (b) ball, and (c) handle-shaft.*

Fishing reel *components require the corrosion resistance of stainless steel.*

Keystone Carbon Co.



lurgy is expanded, applications that require unusual properties also tend to expand. Superior corrosion resistance, oxidation resistance, and retention of mechanical properties at elevated temperatures are available in prealloyed powders. Properties of prealloyed superalloy, stainless steel and nickel alloy powders compare well with those of their wrought counterparts. These properties cannot be matched in blended powders.

The majority of powder metal parts fabricators still blend powder compositions to meet their customers' specifications. The reasons for using blended, rather than prealloyed, powders are simple: they cost less and, because pure metal grains are weaker than alloy grains, require lower pressures to produce a fabricated part. The fabricator who uses prealloyed powders must either produce the parts at a slower rate than needed for blended powders or else use higher tonnage presses. The resulting increase in production costs is reflected in the price paid for parts produced from prealloyed powders.

So the increasing use of prealloyed powders has resulted from the increasing willingness of engineers to pay a premium for alloys not obtainable in powder blends. Stainless steels, tool steels and other highly alloyed compositions cannot be successfully blended. Sintering times, if reasonably commercial, simply do not allow the alloy constituents an opportunity to diffuse through the compact sufficiently to achieve uniform composition. As performance demands increase, it is reasonable to expect that use of prealloyed powders will increase.

TABLE 1—MANY PREALLOYED POWDERS ARE AVAILABLE

Type	Grade
Stainless Steels	302B, 304Si, 309Si, 310, 316Si, 318Si, 347Si, 321Si, 410, 420, 431, 446
Nickel-Base	Monel, Inconel, Inconel X, Nichrome, 50% Iron-50% Nickel, 60% Iron-40% Nickel
Cobalt-Base	AMS 5382, AMS 5385, ML 1700
Low Alloy Steels	AISI 1020, 4040, 4130, 4630, 5150, 8750

Source: Vanadium Alloys Steel Co.; Hoeganaes Sponge Iron Corp.

TABLE 2—LUBRICANTS AFFECT PROPERTIES OF METAL POWDER PARTS[a]

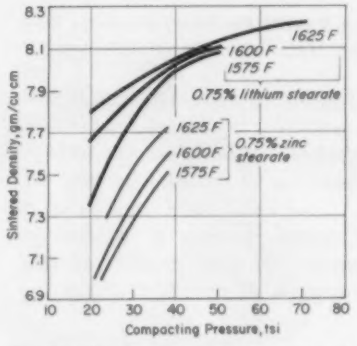
Lubricant[b] ↓	Density, gm/cu cm	Ten Str, 1000 psi
None	6.07	27.6
Stearic Acid	6.38	35.1
Zn Stearate	6.39	37.1
Ca Stearate	6.35	36.1
Li Stearate	6.36	34.0

[a]Type 316 stainless steel —100 mesh powder, sintered 1 hr at 2200 F in hydrogen. Dew point: —40 F. Molding pressure—30 tsi.
[b]Amount of lubricant added, in all cases, was 0.75%.
Source: W. L. Batten, "Application of Stainless Steel Powder Metallurgy," *Progress in Powder Metallurgy*, 120, 16, '60.

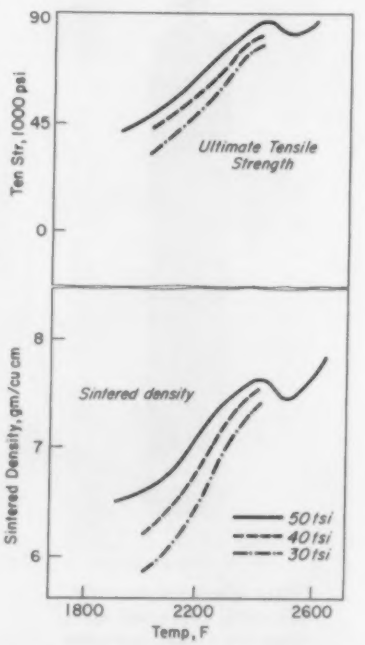
Many compositions available— Table 1 shows a few of the prealloyed powder compositions that are commercially available. The list includes stainless steel, low alloy steel and nickel-base alloys, but many other alloys have been made on a research and development basis. From a commercial point of view, any composition can be produced if an economical quantity is desired.

Mechanical properties can be varied — Mechanical properties vary with pressure, particle size, lubricant used, alloy composition and sintering temperature, to mention five of the most prominent variables. Table 2 shows how the lubricant can affect mechanical properties and density of type 316 stainless steel powder sintered at 2200 F, and Fig 1 shows how mechanical properties of prealloyed 70:30 brass vary with type and amount of lubricant. Table 3 shows the effects of particle size, pressure and sintering temperature on the mechanical properties and density of type 304 stainless steel. Sintering temperature and pressure can be varied to produce a range of densities and mechanical properties in type 316 stainless steel (see Fig 2).

Data are also available on alloy steels, superalloys, and nickel and cobalt-base powders. Alloy steels, particularly a basic AISI 4600 composition in which carbon content is varied to meet specified mechanical properties, are used to meet increased demands for complex parts with high mechani-



1—Density is affected by type of lubricant added to powder. Nitrogen atmosphere was used for lithium stearate addition; hydrogen for zinc stearate addition.
(General Session on Powder Metallurgy, MPIF, '59)



2—Tensile strength and density vary with compacting pressure and sintering temperature.
(Hoeganaes Sponge Iron Corp.)

cal properties. Fig 3 shows how tensile strength of AISI 4630 powder can vary with density.

Superalloys are being investigated on an experimental basis. Discussion at last year's MPIF meeting indicated that Udimet 500 extrusions produced by powder metallurgy techniques tend to exceed the typical properties reported for the wrought material (see Table 4).

2. Precoated powders

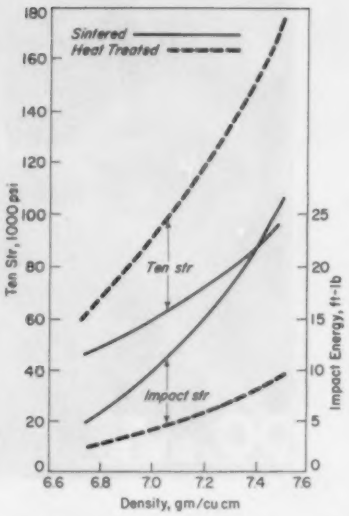
A precoated powder is one in which each grain, theoretically, is individually coated with a metal —or nonmetal. The coating must be an element, not an alloy, since the process consists of depositing the coating material from a carrier gas or from ions in solution. However, individual grains can receive several different coatings of various elements.

Precoated powders are in no way similar to prealloyed powders. In prealloyed powders, the individual grains are identical and uniform in composition with respect to each other and the bulk powder. Precoated powders, on the other hand, offer the designer a composite material which, after sintering, may have properties that differ greatly from those of the individual powder grains.

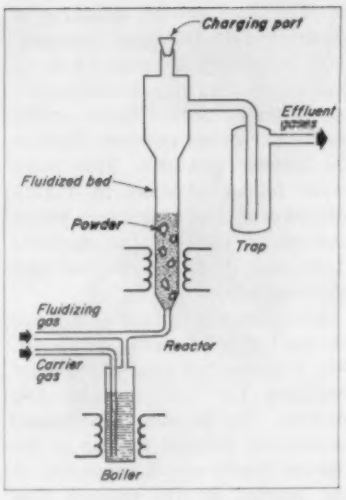
The composite nature of precoated powders may enable designers to decrease cost in much the same way that users of stainless steel-clad plate have reduced theirs. The active metal may be coated on a less expensive powder to permit the use of an inexpensive material in bulk. Thus costs are reduced by placing the more expensive metals only where they are actually needed.

The Atomic Energy Commission is investigating the use of metal-precoated fuel element materials, such as uranium dioxide, for fuel elements in current and proposed nuclear reactors. Fuel elements pressed from such powders should exhibit greater strength than those made from a mixture of ceramic and metallic powders. Also, thermal conductivity, needed to prevent hot spots from forming, should be greater in the metal-precoated fuel element. And in a reactor fueled with a slurry, the metal-coated powder itself might serve as the fuel element.

Precoated powders also offer some processing advantages. Comparing nickel-precoated chromium



3—*Density of AISI 4630 compacts affects tensile and impact strength.*
(Vanadium-Alloys Steel Co.)



4—*Basic equipment required in fluidized bed process used to precoat metal powders.*
(Oxley and Blocher, Battelle Technical Review, July '59)

TABLE 3—PARTICLE SIZE, PRESSURE AND SINTERING TEMPERATURE

Powder Size	Sintering Temp, F	Compacting and Coining Pressure, tsi	Density, gm/cu cm	Ten Str, 1000 psi
−50 Mesh	2100	30-30	5.8	24.5
		40-40	6.25	33.0
		50-50	6.58	42.0
	2200	30-30	5.94	37.0
		40-40	6.36	45.5
		50-50	6.60	60.5
−100 Mesh	2100	30-30	5.68	31.0
		40-40	6.10	44.5
		50-50	6.43	49.0
	2200	30-30	5.84	40.5
		40-40	6.23	54.0
		50-50	6.53	63.5

Source: Grobe and Roberts, *Trans. AIME*, 191, 125.

TABLE 4—PROPERTIES OF UDIMET 500 POWDER METAL EXTRUSIONS
(Heat Treated[a])

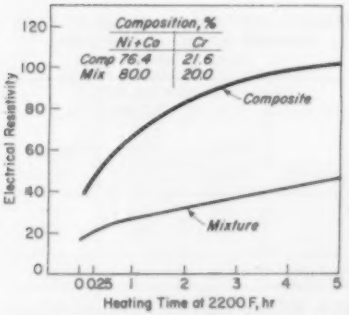
Specimen	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong, %
1	199	143	11.8
2	193	144	9.0
Typical[b]	175	110	15.0

[a]Soln treated 4 hr at 1975 F, air cooled; then aged 24 hr at 1150 F, air cooled; then aged 16 hr at 1400 F, air cooled.
[b]Properties reported in *Utica Metals Bulletin*.
Source: Tous, Davies and Johnson, "Aircraft Superalloys by Powder Metallurgy," *Progress in Powder Metallurgy*, 152, 16, '60.

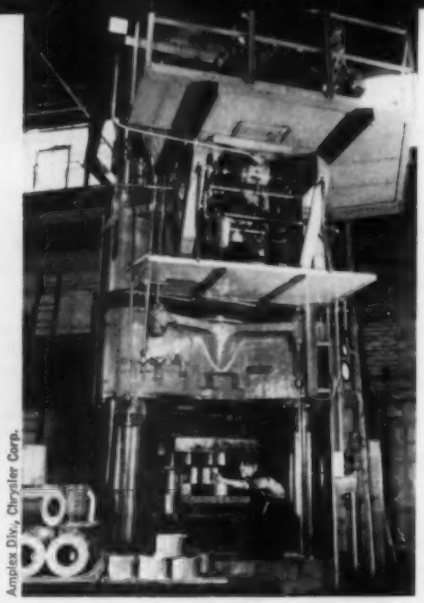
powders with powder mixtures of approximately the same composition, resistivity studies (Fig 4) indicate that homogenization during sintering occurs more rapidly in the precoated powders than in the powder mixtures. This more rapid homogenization in highly alloyed compacts guarantees better uniformity both in the material itself and in its mechanical and physical properties.

How they're made — Coated powders can be easily produced. Fig 5 shows the basic equipment required for the fluidized bed process. The powder to be coated is dropped through the top of the reactor vessel and is supported in the reactor by the upward flow of the fluidizing gas. Because the fluidizing gas maintains a high degree of agitation in the metal powder and assures uniform treatment by the plating gas, thickness of the deposited film can be closely controlled.

An entirely different principle of precoating places the core material to be coated in a suspension containing ions of the metal which is to be deposited on the core powder. This second method, under development by Sherrit Gordon Mines, Ltd., does not always produce a perfect coating on the core materials. This drawback is being investigated and is expected to be eliminated in the near future.



5—*Electrical resistivity of nickel-coated metal powders increases faster than resistivity of powder mixture —an indication that alloying is proceeding faster in the coated powder compact.* (Lund, Krantz and Mackiw)


Amplex Div., Chrysler Corp.

***Giant** of the industry, this 3000-ton press produces parts as heavy as 238 lb.*

3. Large parts

Five years ago (M/DE, Apr '56, p 112) large metal powder parts were described at length in M/DE. The basic statements made then are true now—and to a fuller degree. The largest press in the industry had a 3000-ton capacity; this ceiling has not changed. What has changed, however, is the number of producers in a position to produce large parts. Whereas 100 tons was the maximum-size press made on a "production"—or standard—basis five years ago, 200 and 300-ton presses are now standard production items.

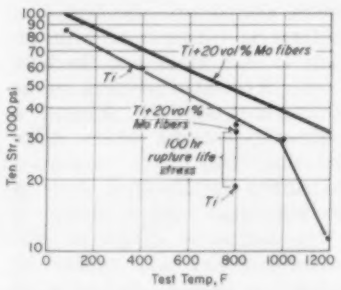
The important point is that the designer now has resources available in the metal powder industry that can more easily respond to his need for larger parts. In the future he can expect capacity to increase further as the need for even larger presses steadily mounts.

4. Reinforced powders

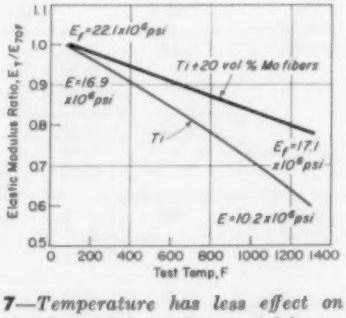
Dispersion hardening by means of oxide additions to aluminum alloys is well known. Recent studies have shown that dispersion hardening can also be achieved by adding fibers to a powder matrix. One requirement: the fibers should either wet or form a coherent bond with the matrix material without forming intermetallic compounds.

Studies of the effects of molybdenum fibers on the properties of titanium powders indicate that:

1. The rapid decrease in strength experienced with titanium above 1000 F is eliminated and 100-hr



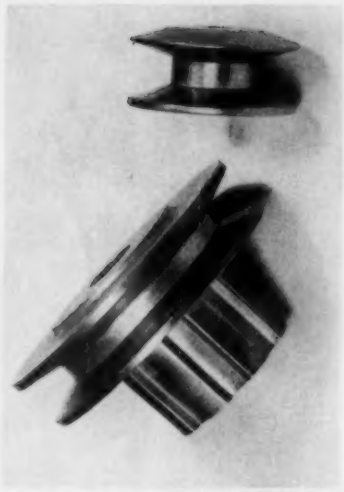
6—*Temperature has a less degrading effect on titanium powder that has been reinforced with molybdenum fiber.* (Clevite Corp.)



7—*Temperature has less effect on elastic modulus when molybdenum fibers are added to titanium powder.* (Clevite Corp.)

Metal Powder Industries Federation

Large gear *of iron powder at right is 4.5 in. in dia and weighs 1.5 lb.*



Amplex Div., Chrysler Corp.

Pulley *represents an advance in metal powder technology. Groove was pressed, not machined, into pulley.*

stress rupture life is increased (Fig 6).

2. Modulus of elasticity of the titanium powder-molybdenum fiber composite is significantly higher than that of a titanium powder part (Fig 7).

Powders dispersion hardened by either oxide or metal fiber additions are not being used commercially to any significant extent. Their properties, however, indicate that they will become increasingly important in the future.

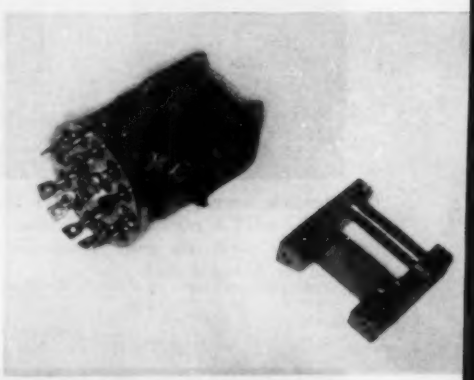
5. Magnetic alloys

Design engineers can now specify magnetic powders for parts that until recently had to be made from wrought materials. Again, powder metallurgy can alter properties, in this case by varying density or heat treatment.

Fig 8 shows how the B-H curve of a 50 iron-50 nickel alloy is affected by density. Although specific data on density are not available, alloy A, with the lowest hysteresis loss, has a higher density than B.

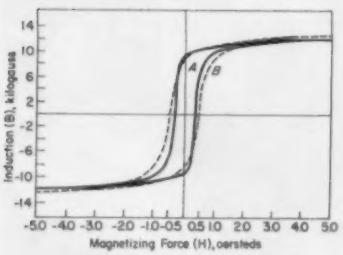
The curves in Fig 9 show how the magnetization curves, and hence the hysteresis loss, of a 3% silicon iron are affected by the heat treatment used to develop magnetic properties. Although unspecified, it is apparent that the type of heat treatment used can affect hysteresis.

As Fig 10 shows, the magnetization curve of the metal powder product is inferior to that of the wrought product. But if the lower electrical properties can be tolerated, you may be able to specify a uniform magnetic part having significantly lower cost than a similar wrought metal product.

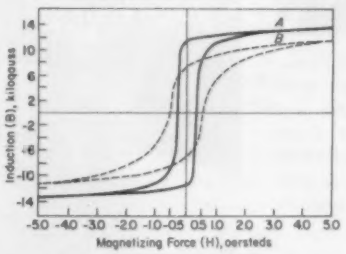


Engineered Plastics, Inc.

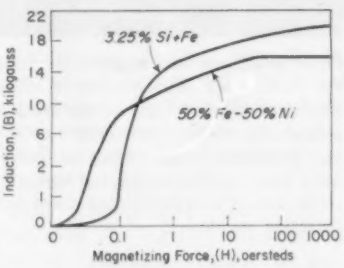
Nickel-iron *pole piece assembly is shown at the right, completed relay at the left. The part, 1 in. long, offers reproducible electrical properties.*



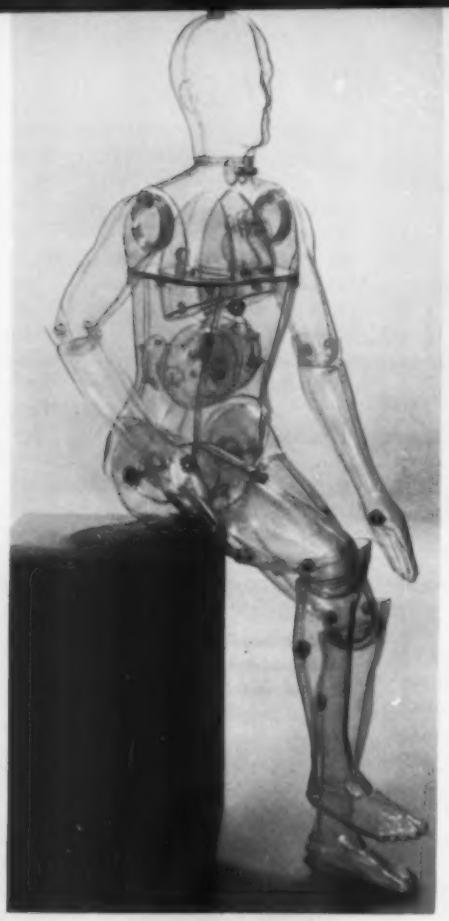
8—*B-H curves for 50:50 iron-nickel alloy show that the highest density powder (A) has the lowest hysteresis loss.* (Engineered Plastics, Inc.)



9—*Heat treatment of 3% silicon-iron powder affects shape of B-H curve. Material A is superior.* (Engineered Plastics, Inc.)



10—*B-H curves for wrought 50:50 iron-nickel and 3% silicon iron show that wrought material has higher induction magnetization than metal powder part.*



Manikin *serves as a radioactive source when loaded with a radioactive solution. The small circular ports are used for dosimeter probes and for filling organs.*

PLASTICS MAN

Is Radiation Guinea Pig

■ The radiations from isotopes concentrated in various parts of the human body are being studied with the use of life-size manikins made of cellulose acetate butyrate.

One reason this plastic is used is that it is almost transparent to x-rays, gamma rays and neutrons. When the manikin is filled with a tissue-equivalent solution, the combination has the same radiation-interaction properties as soft human tissue. After an organ or section of the manikin is filled with a radioactive fluid, the radiation level at any point on the body can be accurately and safely measured.

Cellulose acetate butyrate also has other advantages. It is: 1) easily vacuum formed or injection molded, 2) solvent cementable, 3) tough, 4) transparent, and 5) highly resistant to residual radiation because its water absorption is negligible.

The calibration manikin shown here, "Remcal" (radiation-equivalent manikin-calibration), is made by Alderson Research Laboratories, Inc., Long Island City, N. Y. from material supplied by Eastman Chemical Products Corp.

Body sections and organs *are vacuum formed. Each body segment has a minimum wall thickness of 0.090 in. Large sections are lap joined to resist hydrostatic pressures from the tissue-equivalent solution. Small segments have butt joints. Sealed mechanical joints and ports are either fabricated from bar stock or injection molded.*

Los Alamos Scientific Laboratory

Calibrating a dosimeter *used in liver studies. The liver (the dark organ under the instrument) contains a radioactive fluid. The remainder of the figure is filled with tissue-equivalent solution.*

International Harvester Co.

Deere & Co.

Materials Engineers Help Build

Farm and Construction Equipment

These two industries have made materials engineering an essential part of their organization. This article, based on an M/DE survey, tells what such materials groups are like and what they do.

by John A. Mock, *Assistant Editor, Materials in Design Engineering*

■ Over half of the leading companies in the farm and construction equipment industries have a centralized materials department whose job it is to select, evaluate, and prepare specifications on engineering materials, a recent M/DE survey shows. Top management in many cases refers to these groups as "our captive consultants."

Although recognition of the materials engineering function is becoming more widespread (see M/DE, Sept '60, p 137), it appears to have started earlier in the farm and construction equipment industries than in most other industries. Some companies have had a materials engineering department in operation since the early 1900's when the two industries were beginning to produce equipment on a large scale. However, most materials departments were started during or after World War II.

What are the groups like?

Here is what the survey shows about the size and organization of the groups and the training of its staffs:

▸ *Size.* The size of a materials engineering department in the two industries depends on the size of the company and the complexity of its manufacturing operations. One company employing 70,000 people has a 63-man group whose primary concern is engineering materials, and a company with 27,000 people has a 60-man group that concerns itself with both materials and processes. At the other end of the scale is a company with 1000 people that has a two-man group.

▸ *Training.* Over half of the people employed in materials engineering departments of the companies surveyed are technical graduates. All the engineers in the stress analysis section of one materials group have masters' degrees in engineering. One company reports that about 20% of its staff is attending night school on a tuition-paid basis to gain knowledge in the fields of engineering and science. In addition to formal schooling, the staffs attend seminars and meetings sponsored by engineering societies.

▸ *Quarters.* The importance of a materials group to a farm or construction equipment maker is exemplified by the fact that three leading companies have housed or soon will house their materials department in new and enlarged quarters.

Caterpillar Tractor Co. three years ago opened a new metallurgical and materials laboratory that is equipped to study virtually any material problem (M/DE, Dec '57, p 231). International Harvester houses most of its engineering materials department in a new multi-million dollar research center in Hinsdale, Ill. And Deere & Co. plans to move its materials engineering department to new corporate headquarters now planned for in Moline, Ill.

▸ *Organization.* The titles of people who head the various materials departments in the two industries include: chief research engineer, manager, and administrative assistant to vice president-engineering. As the titles indicate, most materials groups in the farm and construction equipment industries come under the engineering division in the corporate structure. But there are exceptions: the materials department of one company reports directly to management; a group in another company reports to the manufacturing or production division.

Since the materials engineering department is most often considered a captive consulting organization, it typically offers its services to practically all divisions in a company. But the M/DE study shows that the group's services are of particular importance to the engineering and design divisions, followed by research, manufacturing or production, and purchasing.

The most common method of breaking down a materials department in these industries is by materials, the study shows. Of the departments studied, 70% are broken down by type of material and 30% by the products manufactured.

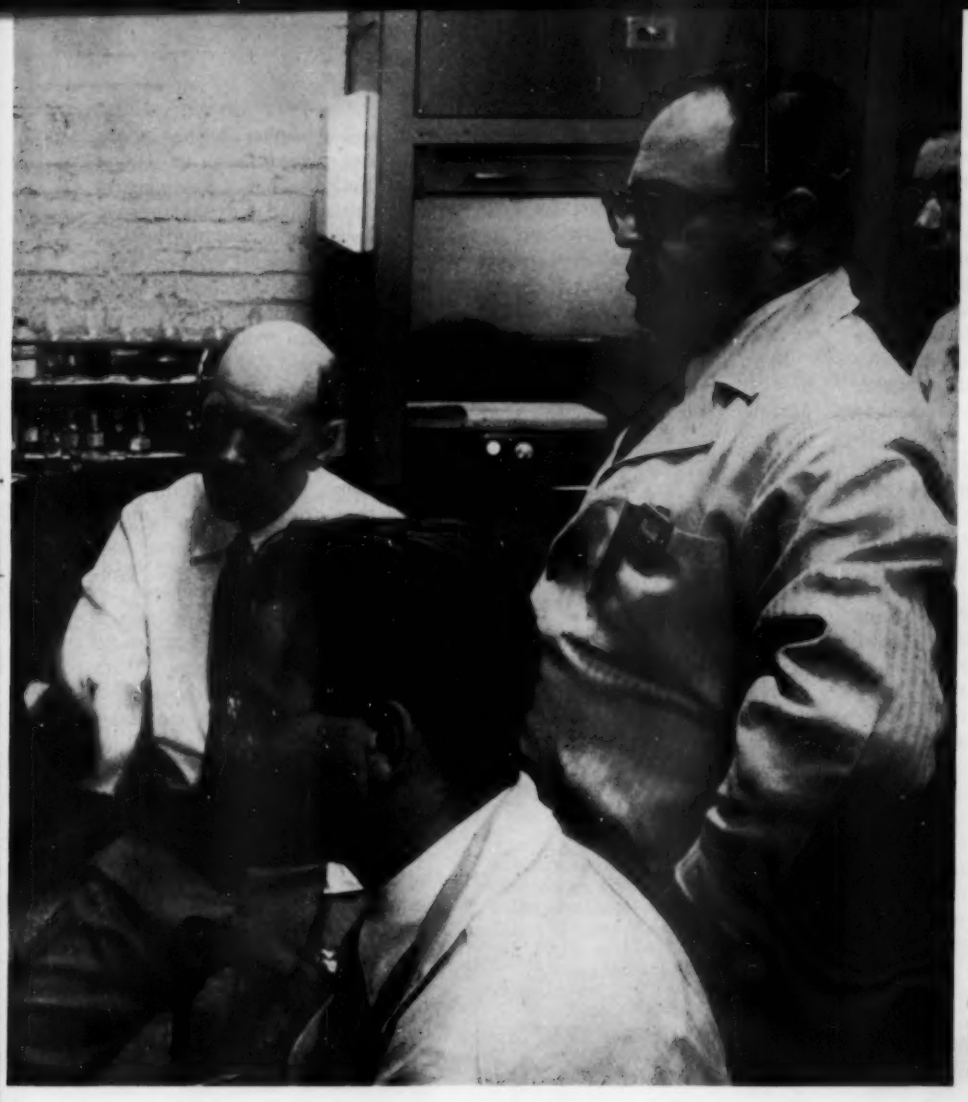
The five big jobs materials

The two most important jobs of a materials engineering department in the two industries are selecting and evaluating materials, and writing specifications and standards on engineering materials, parts and forms. About 90% of the materials groups do a great deal of work in these areas.

But these are not the only jobs. Other work includes: solving materials and process problems encountered during manufacturing; developing and modifying materials to meet product requirements; collecting, organizing and disseminating materials data; initiating materials changes; handling vendor relations; and supervising the testing of materials.

1. Evaluating materials

The whole idea behind a materials department in the farm and construction equipment industries can best be summed up by a recent statement from Newton N. Sacks who heads Deere & Co.'s 60-man materials group. He says the aim of Deere's materials engineering department is "to get the best material into our products



***Materials men** at International Harvester Co. study wear rates of aluminum and phosphor bronze bushings by means of radioactive tracing.*

groups do

in the least amount of time with the least amount of trouble at the most economical cost."

Deere's materials department is broken down into seven divisions or laboratories: 1) chemical, lubrication, paint, 2) mechanical testing, 3) metallurgical, 4) applied mechanics, 5) welding and manufacturing processes, 6) foundry, and 7) standards. The divisions are staffed with such specialists as metallurgical, chemical, mechanical and stress engineers, as well as technicians.

Each of the 18 manufacturing units of Deere & Co. has a design group working closely with the centralized materials department in the selection of materials. Several of these plants also maintain their own materials department. The branch departments are guided in their work by the central department in Moline, Ill.

In the applied mechanics laboratory, specialized engineers work on stress and vibration problems as they relate to new designs. In addition to numerous laboratory measuring instruments, two special trucks are equipped with the materials and instruments necessary to conduct stress analysis in the field under actual operating conditions.

The paint laboratory studies the weather resistance of various types of paint and makes recommendations as to which type of paint is best suited for a particular application. The laboratory exposes painted steel panels to outdoor weather conditions in farm, industrial and salt spray atmospheres. It also runs accelerated weathering tests in the laboratory.

Sacks says, "The best staff work is that which is devoted to materials problems before they occur in production or out in the field.

"Don't catch a materials problem on the second bounce; catch it while it is still on the drawing board," he advises.

New materials—Deere's materials group is also "the open door through which the company looks at new materials," according to Sacks. Take ductile iron, for example. A few years ago the materials engineering department in cooperation with design engineers and other people in the company decided to take a close look at this new material because of the higher strength needed in parts used in more powerful farm and industrial tractors.

The department set up a pilot plant operation and thoroughly studied the material as to melting, casting, strength, wear resistance, etc. The department then analyzed all the data it collected by statistical methods and produced what it believes to be the best available collection of data on the properties of ductile iron.

Another materials group that has done a great deal of work on ductile iron is International Harvester Co.'s 63-man engineering materials group headed by John D. Graham. The centralized department is headquartered in Chicago and Hinsdale, Ill. Harvester has materials engineers at each of its engineering departments.

Special tests—A good idea of how thoroughly Harvester's department works in selecting engineering materials for a company product can be found in a recent research project undertaken by the materials group in cooperation with the company's engineering research section.

Personnel involved first took a special course in nuclear technology, then applied their knowledge to the study and evaluation of bearing materials by means of radioactive tracing. In their work, the researchers irradiated aluminum and phosphor bronze bushings and placed them in a test stand that duplicated pressure, oil temperature and camshaft speed of a diesel engine. During the test, minute particles of copper were worn from the radioactive bushing into an oil bath. The oil circulated around a monitoring device which recorded the radioactivity of the oil. Using a small chip of the same radioactive metal for comparison, the researchers were able to compute the weight of material worn off the bushing and, from this, the quantity of metal removed by wear.

Conventional wear testing methods would have provided an answer, but it might have taken a month or more before wear could be observed in the bushings. "With radioisotopes," the researchers say, "we can measure molecular wear and get our results in 48 hr.

Special truck *operated by members of Deere's materials department is used to record the operating strains, impacts, accelerations and soil forces on farm equipment in actual operation.*

Without teardown we can tell what's going on inside the engine within seconds after it happens. And we don't risk distorting the results by small variations in the way the part may be reassembled after teardown."

The researchers say the technique can also turn up valuable data about wear during an engine's break-in period, a time when wear might be so slight other methods would not detect it.

Emphasis in materials selection varies—At Le Tourneau-Westinghouse Co. in Peoria, Ill., four people in the engineering department have the responsibility of selecting and evaluating materials. According to Wayne H. McGlade, product development manager, the materials group studies cost, processing and quality when selecting a material for a particular application.

Dale B. Mulvany, who heads a three-man materials group at Gar Wood Industries, Inc. in Wayne, Mich., says his group selects engineering materials from the standpoint of 1) function, 2) cost, and 3) weight.

The materials group at Gar Wood played a significant role in helping the design department select materials for a new, compact hydraulic system used in dozers and other mobile equipment. Mulvany says that proper materials selection has considerably reduced weight and hydraulic oil leakage compared to previous units.

In selecting materials for the hydraulic unit, rubber-impregnated asbestos was used in place of leather to reduce leakage, plastics were used in place of cast iron in certain parts to reduce weight, and heat resistant elastomers such as silicone and Viton rubber were used in place of natural and other synthetic rubbers for critical sealing applications.

Selecting and evaluating materials is also a big job of the 50-man materials engineering department in the Tractor Group of Allis-Chalmers Mfg. Co., Milwaukee, Wis. According to Muir L. Frey, manager of the department, processability and engineering requirements are equally important in selecting a material for a particular application. He says it is the job of the materials department to meet the design requirements for materials with materials the plant can fabricate economically.

2. Preparing specifications

Company materials specification and standards handbooks containing more meaningful data is the trend in the two industries. Some companies attach a special bulletin to their specification sheet which provides details on cost, availability, processability and design characteristics of a particular material or part. Illustrations, tables and graphs are being used more frequently than in the past to better explain a material or part.

Although both industries are highly competitive, engineering specification handbooks are freely exchanged among the various companies in the two industries.

Some standards and specifications at Gar Wood are set up along the lines of a military specification, since the company does a lot of military work. Mulvany says Gar Wood's specification handbook gives other people in the company most of the information they need on a material or part.

Cost savings—Fred C. Ewert, who is in charge of engineering standards at Deere & Co., says new paint specifications set up immediately after World War II enabled the company to switch from oleoresinous-type paints to more durable alkyd-base paints at no increase in cost. Recent paint advances also have been reflected in Deere's revised specifications.

According to Ewert, the standards section, after channeling company requirements for bolts and cap screws into four grades, standardized on what is known as the "light nut" with an annual saving of $200,000.

Standards and specifications are also a function of materials departments at Allis-Chalmers Mfg. Co. and Thew Shovel Co.

Thew Shovel Co.'s two-man materials department was founded in 1944 and is headed by chief metallurgist Albert G. Fritsch.

The three-man materials group at Ford Motor Co.'s Tractor and Implement Div. in Birmingham, Mich. leaves standards and specification work up to other people in the engineering department. Ford's department was started in 1950 and reports to the engineering division.

Preparing and writing standards and specifications are two of the most important duties of the materials group at International Harvester Co., according to Donald J. Wulpi, manager of the engineering material specifications section. Harvester's specifications section does a great deal of work in

SUMMARY OF SURVEY FINDINGS

	No.
Companies Surveyed	15
Companies Having Materials Departments	8
When Groups Were Formed:	
Prior to 1940	2
After 1940	6
How Groups Are Broken Down:	
By Type of Material	6
By Product, Part	2
Number of Technical People in Materials Groups:	
1 to 10	4
11 to 50	3
51 to 100	1
Divisions to Which Groups Report:	
Engineering	5
Management	2
Manufacturing	1
Divisions Served by Groups:	
Engineering and Design	8
Research and Development	5
Manufacturing	3
Purchasing	2
What Materials Groups Do:	
Select, Evaluate Materials	7
Prepare Specifications	7
Supervise Materials Testing	7
Review Choice of Materials Selected by Others	7
Solve Manufacturing Problems	6
Develop, Modify Materials	6
Collect, Organize, Disseminate Materials Data	5
Initiate Materials Changes	4
Handle Vendor Relations	4

preparing specifications for most materials used in company products.

3. Helping production

Most of the companies surveyed said their materials department plays a significant role in helping solve manufacturing problems. The problems may involve a material such as cast iron or a process such as welding.

Deere's materials group is well equipped to handle both types of problems, according to Sacks. The department's chemical laboratory uses spectrographic and other modern methods to determine composition of iron, steel, brass, bronze and other materials. Some tests in the mechanical testing laboratory are used for process control. For example, cast iron bars from Deere's foundries are broken daily to check the strength of iron being used. Bolts are tensile tested regularly to see that they meet specifications. Other laboratories perform nondestructive, microscopic and stress tests.

Charles A. Davis, who manages the manufacturing processes and welding laboratory at Deere, says his section keeps tab on welding and machining techniques used in the various manufacturing units of Deere & Co. The laboratory runs tests on welding electrodes and brazing alloys to see that they meet specifications, checks steels for weldability, and trains people in standard and new welding techniques.

Sometimes a materials department makes a part for the manufacturing or production department. For example, Harvester's materials department has rubber molding facilities that are used occasionally for making odd-size or emergency parts for the production department. Other materials groups say they have supplied both metallic and nonmetallic parts to production. But making parts for production is the exception rather than the rule.

4. Developing materials

New design requirements for farm and construction equipment have created a demand for new or modified materials that may not be available from conventional sources of supply. Thus it has become the duty of the materials department to develop new materials or modify existing ones to meet special service or processing requirements.

The M/DE study shows that all materials departments in the companies surveyed do some work in developing or modifying engineering materials. For example, Gar Wood's materials group did a considerable amount of work in cooperation with various suppliers in modifying hydraulic oils used in the company's new hydraulic unit.

And department specialists at Deere & Co. in cooperation with production engineering personnel came up with a new glass-reinforced polyester compound for use in a tank holding insecticide sprays. The glass-polyester tank replaced an aluminum tank at a cost saving.

The materials department at International Harvester Co. has 1) modified permanent-type antifreeze to meet new company specifications, 2) developed new and improved methods for applying nylon coatings to metal, and 3) worked with the company's Wisconsin Steel Div. in modifying and developing new types of steel.

5. Disseminating information

Preparing a specification handbook requires a lot of searching in technical magazines, books and suppliers bulletins. Accordingly, all materials groups in the two industries have technical libraries that contain the latest periodicals and books on engineering materials and processes.

International Harvester's Wulpi has set up an extensive file of articles pertaining to the properties and uses of all types of engineering materials. The file is kept up-to-date and referred to frequently for writing specifications, standards and handbooks on engineering materials and processes.

Deere's materials group has written extensive reports and conducted a series of informal meetings with other people in the company to point out the advantages and limitations of ductile iron.

Materials Progress and the Plow

Engineering materials and processes have played an important role in the development and improvement of the basic farm tool, the plow. Up until the late 1700's farmers went along for thousands of years with little or no improvement in plow design. Then came a period here in America when this basic tool made more progress in one generation than in all previous history.

Thomas Jefferson used principles of mathematics in 1788 to make plow moldboards more efficient. And in 1797 a cast iron plow was patented. The iron plow met with resistance at first because of fear that it poisoned the land and caused weeds to grow. Nevertheless, the idea of casting in one piece later opened the way to mass production of identical machines from the same pattern.

A great turning point in the production of food came in the 1830's with the development of the steel plow by John Deere. The steel plow greatly improved the quality of plowing and enormously reduced the amount of power needed. One writer of the time estimated that the steel plow "cut by at least a third the animal power needed for turning the soil."

In 1868, soft-center steel for the plow moldboard and share further improved the plow and curbed its tendency to crack, bend or warp.

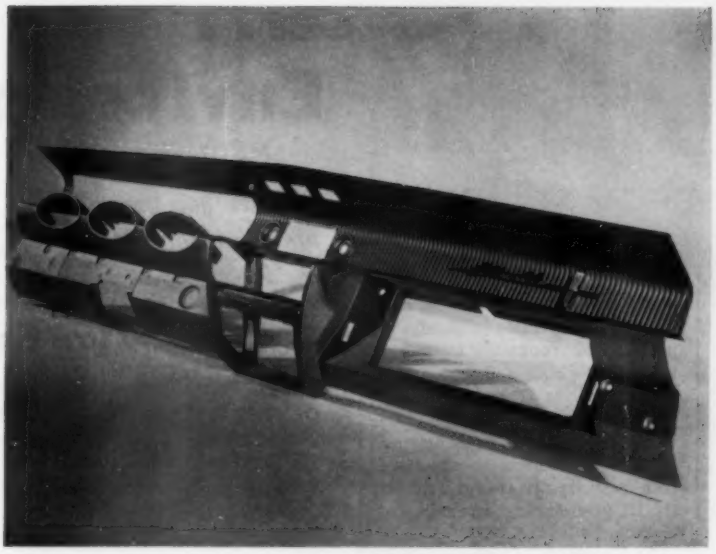
The chilled plow, long a goal of plow makers, became a success about 1869. Chilling produced a hardened surface without brittleness, resulting in a longer wearing plow.

Acknowledgments

We would like to express our appreciation to all those who cooperated in the survey, and particularly to the many helpful people in the following companies and societies:
Allis-Chalmers Mfg. Co.
Deere & Co.
Farm Equipment Inst.
Gar Wood Industries, Inc.
International Harvester Co.
Le Tourneau-Westinghouse Co.

One-Piece Zinc Die Casting

This unit used in the standard 1961 Oldsmobile is said to be the largest, one-piece interior die casting ever used in the automobile industry. Although the console is over 4 ft long, more than 1 ft wide and 5 in. deep, it weighs only 20 lb. Doehler-Jarvis Div. of National Lead Co. says it encountered no production difficulties in making this complex, thin-walled casting from a New Jersey Zinc Co.'s Zamak 3 alloy for the entire line of standard-size Oldsmobiles.



Two New Dashboards

Instrument Housing of ABS Plastic

The housing for the dashboard instrument cluster in the 1961 Buick Special is molded from high impact ABS (acrylonitrile-butadiene-styrene) plastic. The instrument circuit is die cut from thin copper sheet and bonded onto the rear of the housing.

The ABS used is Kralastic, made by Naugatuck Chemical Div. of United States Rubber Co. The housing was designed and is being produced for Buick by General Motors' AC Spark Plug Div.

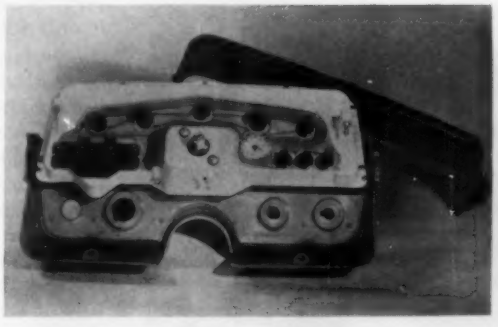
ABS plastic was selected for the cluster because of its economy and weight advantage over metals, and because its nonconductivity permits the use of printed circuits that eliminate the usual wire tangle.

The cluster was molded in three sections and joined with self-tapping metal fasteners. It weighs 2.3 lb, one-fifth as much as traditional die cast metal clusters.

The unit survived rigorous tests before production. These included driving a test car 25,000 miles in GM's desert proving grounds, and shake and impact tests. In high temperature resistance tests it withstood up to 220 F.

Front view

Rear view



How Good Are

Environmental Tests

About This Article

The performance of elastomers exposed to environments such as heat, cold, weather, ozone and fluids is extremely difficult to predict. Environments are variable, and the standard tests available—many of them accelerated tests—can seldom be correlated with specific service conditions. Results of most such standard test methods are useful primarily in preliminary screening of elastomers.

The purpose of this article is to outline the types of tests available for measuring environmental deterioration of elastomers, and to indicate how useful the results of such tests are in predicting service performance. Bear in mind that in evaluating any elastomer the ultimate criterion is whether it will perform its function satisfactorily after exposure to service conditions. (A similar discussion of mechanical properties and tests appeared in M/DE, Aug '59, p 105.)

Since a general understanding of the test method is essential to an understanding of the limitations of test results, a brief summary of the standard tests used is given in the table on p 126. In the following discussions, the "D" numbers in parenthesis refer to the ASTM tests outlined in the table.

Heat—*Section of standard rubber heat resistant conveyor belt shows effect of salt at 300 F on rubber top cover (left) and bottom cover after six months service.*

Be sure you know how to interpret the effects of . . .

1. High and low temperatures

Heat resistance—The specific effect of heat on an elastomer depends on the type of elastomer, its formulation and the test conditions. Test results are usually given as the change in tensile properties and hardness caused by exposure to either 1) a given temperature (D454), or 2) a selected temperature representative of expected service (D573, D865).

Rate of deterioration increases logarithmically with temperature, so that relatively small changes in temperature cause large differences in degree of deterioration. Also, exclusion of oxygen, as by immersion in a fluid or confinement between flanges, greatly retards the rate at which deterioration occurs.

Consequently, 1) the heat resistance test should include a control specimen whose performance in service is known, and 2) test conditions should approximate service conditions as closely as possible. For example, specifications based on the maximum operating temperature of the equipment may give an entirely false picture of the life of a resilient part in the equipment. The part itself may never reach this temperature, or may be exposed to it only intermittently.

Effects of cold—All the changes in an elastomer caused by exposure to low temperatures are reversible, i.e., the elastomer regains its original properties when returned to room temperature. Low temperature effects can be classified as short-time and long-time effects.

Short-time exposure to cold results in two important phenomena. They are:

1. Simple stiffening—As an elastomer is exposed to successively lower temperatures its becomes progressively more difficult to stretch or bend. This stiffening is gradual until a so-called second order transition temperature is reached.

2. Second order transition—At this temperature, stiffness increases sharply. Second order transition usually begins at about –20 or –40 F, specific values depending on the base elastomer and on compounding.

After this increase in stiffness, further cooling produces little effect. At some temperature within this transition range, the elastomer becomes brittle enough to shatter on sudden bending or impact. The specific temperature depends on the rate of loading. Under standard test conditions this temperature is called the "brittle point."

Long-time exposure to cold produces two other kinds of changes. In certain types of elastomers, such as natural rubber, butyl and neoprene, long-time exposure to moderately low temperatures (about 0 F) produces crystallization. Although crystallization results in an increase in stiffness, it does not necessarily result in brittleness. Nor does it affect the brittle point of the elastomer. For each type of elastomer, there is a temperature at which crystallization takes place most rapidly.

The second type of long-time effect involves the plasticizer. Most compounds designed for low temperature service contain special plasticizers to improve low

for Elastomers

temperature flexibility and to lower the brittle point of the compound. Upon prolonged exposure to cold, the compatibility of a plasticizer with the elastomer is reduced, and a portion of it may be thrown out of solution. This can result in greater stiffness at temperatures above the brittle point, and an actual increase of several degrees in the brittle point. Generally, such plasticizer-time effects occur only after prolonged exposure at extremely low temperatures, such as –40 F, and only when large quantities of certain plasticizers are used.

Brittle point, as determined by the standard test (D746), has little relationship to stiffness; stiffness measurements involve low rates of loading and low deflections, whereas brittle point measurements involve high speed loading and high deflection. Also, results of the test for brittle point give only one indication of low temperature flexibility. Brittle point values can be used for comparison between elastomers, but they depend so much on the rate at which load is applied that stiffness tests are usually used in conjunction with them.

Of the stiffness tests, torsional stiffness measurements (D1053) are probably the most satisfactory. They give values for relative stiffness which are easy to interpret, and the deflections employed in the test closely resemble those usually encountered in service.

The simple beam test (D797) provides data from which it is possible to calculate Young's modulus of elasticity—a property readily understood by engineers. However, modulus of elasticity data for elastomers can only be obtained at low deflections; in service, elastomers are usually subjected to deflections that are appreciably higher.

The hardness test (D676), because of its simplicity, is probably the most widely used indicator of low temperature stiffness. However, it does have the drawbacks inherent in durometer hardness measurements. Results are difficult to reproduce accurately. Furthermore, specimens tested at low temperature frequently display "drift," so that instantaneous readings are followed by a drop in hardness.

2. Outdoor and indoor aging

Outdoor aging — Effects of weathering are usually 1) ozone cracking of stretch rubber, 2) surface oxidation, causing the formation of a surface skin which becomes hard and resinous, and eventually crazes, and/or 3) decreased tensile strength and extensibility of the entire mass. The rate and extent to which these changes occur depend on exposure conditions and, to a great degree, the elastomer composition.

Accelerated laboratory tests (D750) exaggerate the ultraviolet region of the sun's spectrum and give little weight to the degradation known to take place even in the absence of sunlight. Consequently, results of such tests are difficult to correlate with outdoor service performance.

Actual outdoor exposure tests (D518, D1171) are a closer approach to service conditions, but reproducibility is poor. Results depend heavily on local climate and atmospheric conditions, such as industrial residues.

Conclusions based on tensile tests after exposure may be misleading. Results are markedly affected by the extent and type of surface cracks caused by exposure. Frequently such tensile tests are more similar to tear tests because of the nicks or cracks on the edge of the specimen.

Aging—*Good and bad aging resistance are shown in these two sections of elastomer-insulated telephone cable in use for 14 years.*

Indoor aging—During storage, an elastomer may crack, or become soft and gummy, or become hard and inflexible. Most storage deterioration is caused by the action of oxygen and ozone, often accelerated by heat.

As stated in the ASTM test methods (D572, D454, D573, D865, D1206), no direct correlation between the tests and actual life of the elastomer is implied. Results should be used primarily for comparison.

Tensile strength, elongation and hardness in elastomers are extremely sensitive to degradation. If they change very little during aging, chances are that other physical properties have been relatively unaffected. The fact that tensile strength drops off, however, is no proof that other physical properties have deteriorated to a like extent.

3. Ozone and corona

Attack by ozone (an allotropic form of oxygen) is usually evidenced by formation of either a few deep cracks or a myriad of small cracks. Ozone attack is common, as ozone is universally pres-

ent in the atmosphere. It is generated from oxygen in the air by ultraviolet light (from sunlight), or by high voltage discharge (such as corona). Ozone concentrations vary. One to five parts per hundred million are common in rural areas; as much as 50 pphm has been measured in Los Angeles smog.

Corona, the electrical discharge which takes place in the atmosphere around high voltage cable, causes erosion in some types of plastics. However, its principal effect on elastomers is that caused by the ozone generated by the corona, both in the atmosphere around the cable, as well as in the air occluded within the cable.

Of the many variables affecting the results of standard ozone tests (D1149, D470), the most significant are ozone concentration, test temperature, and stress in the specimen. Higher temperatures and ozone concentrations increase rate of attack.

The effect of stress is complex. Unstressed elastomers are attacked by ozone slowly if at all. Slight stresses (sufficient to cause as little as 2% elongation) can cause the specimen to exhibit deep ozone cracks. As stress is increased, the severity of these cracks may pass through a maximum, often at that point when the rubber is extended to about 10% elongation. At elongations of 25 to 100%, attack is indicated by many small cracks. Consequently, if a part will be subjected to varying stress in service, its performance cannot be predicted by ozone tests run only at the highest stress.

Stress relaxation characteristics of many elastomers are such that they may pass ozone tests easily even though their ozone resistance may be poor. To overcome this effect, ozone tests can be run at a constant stress rather than constant strain.

Ozone—*Tire at right shows ozone cracking; tire at left with equivalent mileage shows effects of compounding for ozone resistance.*

4. Fluids

Oil resistance — Rubber parts exhibit two effects when exposed to a liquid hydrocarbon: 1) changes in dimensions, and 2) deterioration of physical properties.

Where dimensional stability is functionally necessary, such as in o-rings or small bore tubing, swelling will disqualify an elastomer regardless of its retention of other physical characteristics. In many cases, however, if original mechanical properties have not been impaired to the point where the elastic member fails to give satisfactory service, volume change may be of little significance.

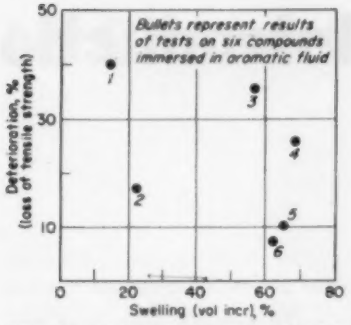
Results of standard tests (D471) have no direct correlation with service performance. One important difference between test conditions and most types of service is the nature of exposure. Standard tests are immersion tests, and rarely, in service, is a rubber part completely immersed. Usually, only one side of the part is exposed to the fluid, as with hoses and gaskets. Also, such exposure is often intermittent. The

STANDARD TESTS FOR EFFECTS OF

ASTM Test	Description
EFFECTS OF HIGH AND LOW TEMPERATURES	
D454	**Heat—given temperature.** Air pressure heat test; tensile properties measured before and after exposure to air at 80 psi, 260 F; time variable from 3 to 30 hr
D573, D865	**Heat—selected temperature.** When effects of specific service temperature desired, specimen tested at desired temperature in air oven (D573) or test tubes (D865); tensile properties and hardness measured before and after test
D746	**Cold—brittle point.** Specimen clamped so that it acts as a cantilever beam; after few minutes conditioning at test temperature, specimen struck by motor-driven or solenoid-actuated striking arm moving at 6.5 ft/sec; specimens tested at successively lower temperatures until a specimen breaks into two or more pieces; temperature at which this occurs is designated Brittle Point
D1053	**Cold—torsional stiffness.** Gehman torsional apparatus measures degree to which specimen twists under definite torque applied through torsion wire; extent of twist measured at room temperature and low temperature; provides values for relative stiffness modulus
D797	**Cold—flexural modulus.** Simple beam specimen supported at ends, loaded at center; measurement of deflection at various temperatures under known load permits calculation of modulus of elasticity in flexure
D676	**Cold—hardness.** Simple temperature effects determined by plotting durometer hardness against temperature; to determine time effects, specimen conditioned at constant temperature and hardness plotted as function of time
EFFECTS OF OUTDOOR AND INDOOR AGING	
D518	**Outdoor aging—actual exposure.** Specimen strained to 20% elongation or bent in form of loop and subjected to outdoor exposure; time until just before first minute surface cracks or checks appear is reported. Note: many variations on test have been developed for given sets of service conditions; e.g., for tire sidewall evaluation, specimens are continuously flexed outdoors to determine additional effect of varying strain
D1171	**Outdoor aging—automotive.** Outdoor exposure test developed for automotive compounds; triangular-cross-section specimens strained around mandrel and exposed; results rated as follows: #0—no cracking visible at 2x magnification, #1—cracking not visible at 1x but visible at 2x magnification, #2—small cracks visible at 1x, #3—medium size (or larger) cracking
D570	**Indoor aging—accelerated.** Specimens exposed in device such as Weather-O-Meter; light from carbon arcs has spectrum similar to that of sunlight; after given exposure time, deterioration judged both visually and by decrease in tensile strength and elongation
D572	**Indoor aging—accelerated.** Oxygen pressure method; specimens exposed to pure oxygen

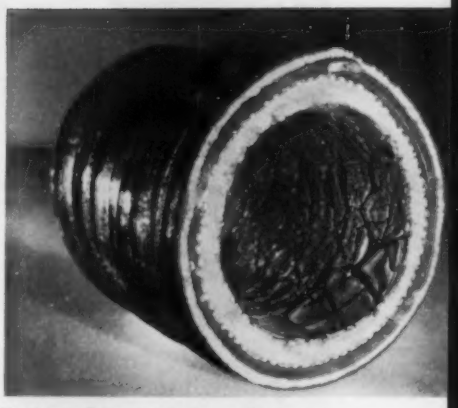
difference between such exposure and total immersion is so vast, in terms of effects produced, that service life cannot be predicted on the basis of test results.

A common fallacy is to assume that rubber compounds that show the largest volume swell on exposure to oil are the most degraded by this exposure. This is not true. Often there is no correlation between volumetric change and property deterioration. The accompanying graph clearly shows this lack of correlation. The six points represent effect of immersion on six rubber compounds in an aromatic test fluid, as measured both by volume swelling and by loss in tensile strength. It is obvious that deterioration does not increase as swelling increases. In fact, compound 1 swelled least, but its tensile strength deteriorated most; compounds 5 and 6 swelled most, but their tensile strengths were least affected.



***Effects of immersion** of six different elastomers in an aromatic test fluid, both in terms of volume increase and tensile strength decrease. As can be seen, there is no correlation.*

Water resistance — Although rubbers traditionally have been associated with water repellency, all natural and synthetic elastomer compounds absorb some water; compounding ingredients, rather than the elastomer itself, being the primary cause. Hydrophilic compounding materials increase absorption of the compound; water soluble ingredients may cause degradation of the compound as well as contamination of the water or water solution.



***Fluids**—Conventional rubber hose used for handling acid is unfit for use after less than two months service.*

Chemical resistance—An elastomer can fail in a chemical environment in two ways: 1) degrading until it no longer performs its function, or 2) contaminating the chemical environment without itself becoming seriously affected.

There are no standard tests for chemical resistance of elastomers. There are too many types and concentrations of chemicals to develop meaningful standard reagents; and the degree of degradation tolerable in a rubber part depends on the specific design requirements of that part.

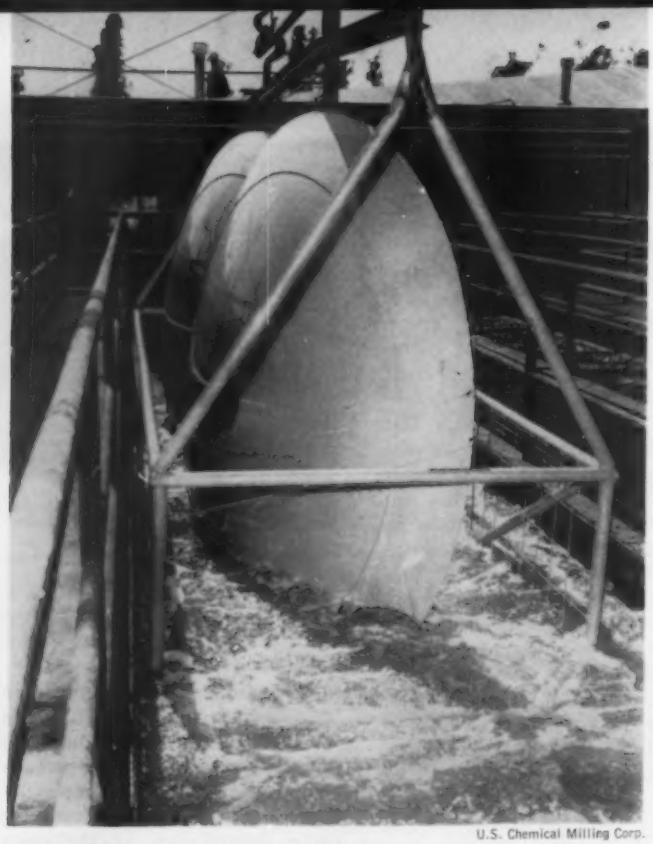
Laboratory immersion tests can be used to eliminate utterly unfit elastomers from further consideration. But such tests cannot distinguish between fair and good.

The best method of developing optimum rubber products for chemical service is to rely on the rubber supplier's experience. By giving him the details of your design requirements and anticipated chemical environment, you can get the best compound for your specific use.

ENVIRONMENTS ON ELASTOMERS

ASTM Test	Description
EFFECTS OF OUTDOOR AND INDOOR AGING (Continued)	
	at 300 psi, 158 F for variable time periods in "oxygen bomb;" tensile properties and hardness determined before and after test; occasionally other property determinations are made
D454	Same as D572, except specimens exposed in pressure chamber to air at 80 psi, 260 F
D573	Same as D572, except specimens exposed in circulating air oven at 159 F, or other desired temperatures
D865	Same as D572, except specimens exposed in heated test tubes
D1206	**Indoor aging—creep.** Specimens exposed at constant load to temperatures in circulating air oven; dimension between bench marks measured at regular time intervals
EFFECTS OF OZONE AND CORONA	
D1149	**Ozone—20% strain.** Thin, rectangular test specimens clamped at elongation of 20%, conditioned at room temperature for 24 hr and placed in chamber; air at prescribed temperature (usually between 90 and 120 F) with ozone concentration of 25 ±5 pphm circulated across specimens; results usually reported as time to appearance of first cracks. Note: temperature, dimensions of specimens, mounting technique and ozone concentration must be reported
D470	**Ozone—bent on mandrel.** Severe test designed for wire and cable covers; specimen must show no injury after being bent around mandrel and exposed to ozone for 3 hr; ozone concentration designated by product specification, usually at 100-150 pphm
D470	**Corona—typical.** Test used by some public utilities for power cable specifications is: no damage resulting from application of 100 v (60 cps, d.c.) per mil of insulation thickness to a length of cable bent to a U shape with bottom of U resting on grounding plate
EFFECTS OF FLUIDS	
D471	**Oils, water—immersion.** Procedures for immersing test specimens in liquids under definite conditions of temperature and time; temperature selected from standard list to simulate anticipated service conditions; time usually varies from 22 hr to 30 days; results reported as change in weight, volume, tensile strength, elongation or hardness. Unless liquid is to be contacted in service is of constant composition, a standard test liquid covering range of properties that may be encountered should be used: ASTM No. 1 Oil is low swelling (aniline point, 255 F); No. 2 is medium swelling (aniline point, 199 F); No. 3 is high swelling (aniline point, 158 F); Reference Fuel A is 100% isooctane; Reference Fuel B is 70 isooctane-30% toluene (by volume)

Adapted from *The Language of Rubber*, E. I. du Pont de Nemours & Co., Inc., '57.



U.S. Chemical Milling Corp.

Large parts *such as these missile bulkheads are formed and chemically milled to close tolerances.*

Introduction

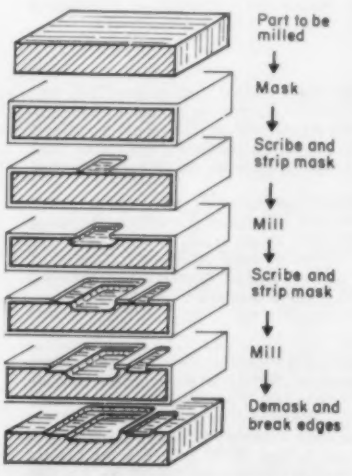
This metal removal process cannot compete with simple, low cost mechanical methods, but it is an attractive alternate to expensive tooling and machining. Consider chemical milling when shapes are difficult to machine or when you require smooth surfaces.

by J. B. Mohler, *Boeing Airplane Co.*

■ A number of well established commercial processes are based on chemical removal of metal from surfaces. The engraved plates used to produce the illustrations in this magazine are a good example of how an etching reaction is put to use. Chemical milling, a more recent development, has as its aim uniform removal of metal at a controlled rate to dimensionally change parts and produce commercially acceptable surfaces. The process removes 2 to 4 lb of steel per min from a 100-sq ft surface.

Chemical milling is basically a three-step process: A maskant is applied to protect surface areas that will not be milled. The metal is immersed in an etching bath, which may be acidic or basic, to remove metal from specific areas so as to produce the desired configuration. Finally the maskant is stripped from the part.

To produce a simple shape, the masking and milling procedure is only performed once. Complex designs are usually produced by repeating the masking and milling sequence until the desired shape is achieved. The drawing below illustrates the sequence used to produce a step pattern—a series of masking and milling operations.



Complex shapes *are produced by a masking and chemical milling sequence.*

Although the milling solution is similar to a pickling solution, some elements of chemical brightening solutions are added. Thus, chemical milling is a compromise between pickling and chemical brightening: metal is removed at a uniform rate without excessive local attack or roughening of the milled surface.

Designs normally not considered producible by mechanical means can be considered for the chemical milling process. Two examples of expensive or difficult processes: removing metal from an extremely complex surface, and removing metal from very thin sections. These two operations are considered routine for chemical milling.

In this article we will discuss

to Chemical Milling

the metals that can be chemically milled, design possibilities and limitations and, to a limited extent, techniques. Masking materials, an essential aspect of chemical milling, will be discussed in a separate article next month.

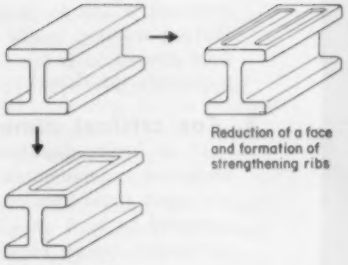
The four big advantages

1. Weight can be reduced—The sketch at right shows how the weight of a forged section can be reduced when the entire mass of the part is not considered essential to design strength requirements. A large volume of metal is removed to form bosses or strengthening ribs. Thus, chemical milling helps to achieve lightweight designs.

In contrast, brazed, welded or mechanically attached ribs often impose penalties: using mechanical fasteners adds the weight of the fasteners to the component; and thermal techniques are limited by potential warpage, increases in residual stresses, and loss of strength.

2. Mechanical properties are not affected—Hardened metals are milled as easily as their annealed counterparts. The fact that mechanical properties are not affected accounts for the use of chemical milling on many parts that normally would be machined or ground to achieve a desired contour.

3. Complicated shapes are possible—Chemical milling can be used as an alternate to contour mechanical milling when complicated shapes must be considered. Curved sections, upper and lower surfaces, and internal surfaces are easily milled.



Two aims—*Chemical milling can be used to reduce weight and size and strengthen a component at the same time.*

4. Processing costs are low—One distinct advantage of chemical milling is that relatively unskilled labor can be used. Skill akin to that required for electroplating, rather than that of a machinist, is all that is needed.

Tooling itself is relatively inexpensive and consists of a planned layout for stripping the maskant from areas to be milled. When a large number of similar parts are to be made, templates for marking the maskant are formed from plastics, aluminum or magnesium.

Although handling equipment is expensive, the cost must be considered in relation to the cost of machining a complicated surface by mechanical processing methods.

Many metals can be milled

A list of metals that can be chemically milled would include essentially all of the common metals and most of the less common ones. Aluminum, magnesium, titanium, tool steels, stainless steels, monel, Inconel and various superalloys have been successfully milled. Less common metals—such as molybdenum, tungsten, beryllium and tantalum—have been milled, but experience with them has been limited by the lack of demand. Experience, time and experiments are needed to develop proper milling solutions.

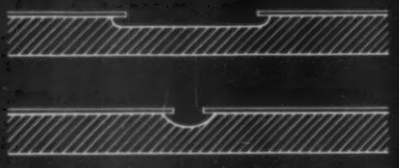
Soundness is important—Wrought, extruded and cast metals can be milled. However, sound, homogeneous metal is required to achieve a uniform metal removal rate. Experience shows that:

1. Successful results can be obtained with wrought sheet that has been uniformly heat treated and stress relieved. Warpage is encountered when residual stresses, caused by heat treating or mechanical shaping, are relieved by the milling process. Proper tempering and stress relieving procedures are therefore a part of the overall process.

2. Castings and extrusions can be successfully milled. Of all the metal forms, castings are the most troublesome to shape because of the difficulty encountered in obtaining sound, uniform, fine grained material.

3. Weldments should be avoided because of possible differences in milling rates associated with differences in structures and stresses in the welded zones.

For design and process pointers, turn page



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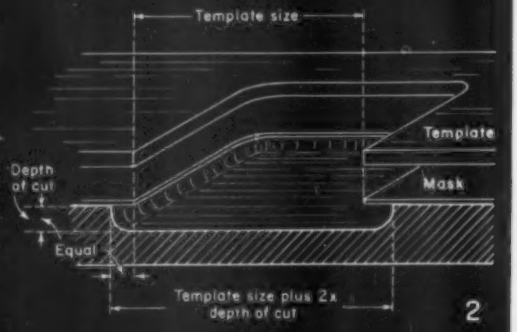

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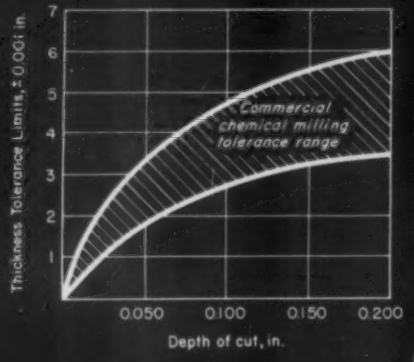

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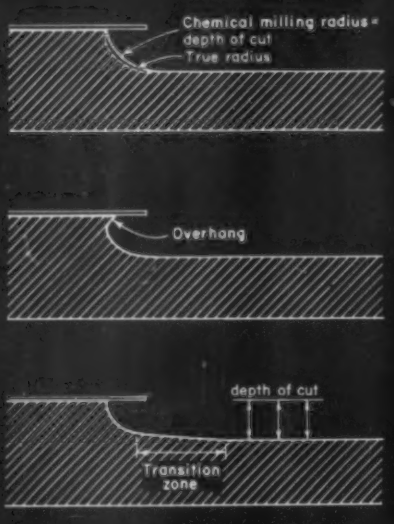


8a

12 Pointers for

1. ***Solution agitation***—During milling the solution must be vigorously agitated. Any surface that reduces flow will reduce the milling rate in local areas. For example, narrow grooves reduce solution flow, causing a "dishing" reaction. See drawing for difference between a narrow and a wide groove after chemical milling.

2. ***Template size vs final size***—The relationship between the template size and final width of a milled area is shown in the drawing. The template is used as a guide to scribe the maskant which is then stripped from the areas to be milled. During milling, metal is removed under the mask so that the final dimension is template size plus total undercut. Undercut is approximately equal to depth of cut.

3. ***For critical dimensions, predetermine undercut***—If an inside dimension is critical, determine the amount of undercut experimentally before actual production begins. The undercut ratio (undercut divided by depth of cut) is usually assumed to be 1 ± 0.15. If this tolerance is too great for a particular design requirement, you must determine the undercut ratio precisely.

4. ***Minimum widths***—Although dishing (see first drawing) occurs in narrow grooves, it is possible to mill an exposed area as small as 1/16 in. wide. The resulting groove width will be 1/16 in. plus twice the depth of cut. Narrow lands can also be chemically milled, but stripping of the mask becomes critical at about 0.1-in. land width. Final milled land width, of course, is template size minus twice the depth of cut.

5. ***Thickness tolerance***—Chemical milling thickness tolerances must be added to the original tolerance on part thickness. Although a tolerance of ±0.001 in. has been claimed for cuts up to 0.060 in. deep, this figure falls into the "special" tolerance category. Expected commercial tolerances fall into the general range shown in the graph.

6. ***Line definition***—Deviation of a milled line from a true straight line is called "line definition." Line definition of ±1/32 in. is regarded as commercial.

7. ***Maximum surface area***—Chemical milling techniques are frequently applied to problems involving metal removal from large areas. These areas can consist of a single large piece, a number of small pieces, different parts, or different surfaces on the same part. With equipment now available, the maximum surface area that can be chemically milled is greater than 400 sq ft.

8. ***Radii***—Chemically milled radii are approximately equal to the depth of cut and are not as reproducible as radii obtained by mechanical processing. The drawing (8a) shows deviations from the true radius. Three particular situations to consider are:

   Overhang. Insufficient solution flow—a correctable condition—is the usual cause of overhang. Even without overhang, a sharp edge, which represents a handling hazard, is usually pro-

Chemical Milling

duced and should be broken.

Transition zone. Consisting of a slight taper about 2 to 10 times the depth of cut, the transition zone occurs between the radius and point at which uniform depth of cut begins. Shape of the radius and transition zone depend on the amount of agitation and type of solution. If dimensions are critical in this area a pilot specimen should be run to determine processing limitations.

Effect on existing radii. It is often advantageous to bend a part before milling. Note the drawing (8b). The finished inside radius is the original bend radius plus the depth of cut. Outside radius is the bend radius minus the depth of cut.

9. *Combine chemical and mechanical finishing*— Chemical milling should be considered as a step in the overall process of producing a finished part. Mechanical finishing can supplement chemical finishing even at the chemical finishing stage.

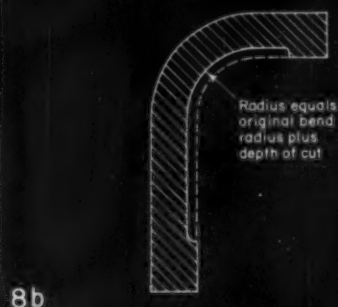
Edges can be trimmed as a mechanical finishing aid. Radii and transition zones can be mechanically finished if required. As the drawing shows, chemical milling may be used to reduce the interior or exterior wall of tubing when mechanical reduction is costly because of the thinness or hardness of the metal. In such cases, mechanical trimming of the tube ends may be more economical than the steps associated with masking, if the wall is milled to the edge.

Mechanical methods are helpful in final finishing of complex parts. For example, two converging tapers are difficult to match by multiple masking and milling steps. The two tapers can be milled separately, however, leaving a gap between them which can be mechanically blended.

10. *Avoid crevices*— Narrow crevices and lapped joined edges, such as those illustrated, cannot be exposed to a chemical milling bath without being attacked. Such areas must either be avoided completely or fully masked and finished mechanically, if finishing is necessary.

11. *Edges*— When the entire edge of a part must be milled, a good edge cannot be reproduced if excessive metal is removed. The drawing shows that a round edge cannot be reduced more than 25% and a square edge more than 15% without resorting to mechanical trimming. A round edge is more easily treated by chemical milling than a square one. When an edge must be protected, the mask must not only cover the edge completely; it should also be placed on all adjacent surfaces to prevent loosening of the mask during milling. When a milled surface is required up to an edge, mask the edge and then trim it after chemical milling is completed.

12. *Holes*— When holes are required in a chemically milled area, drill them after the milling operation is completed. The more expensive alternate method requires masking of holes and adjacent surfaces. The unmilled metal adjacent to the hole must then be removed mechanically.



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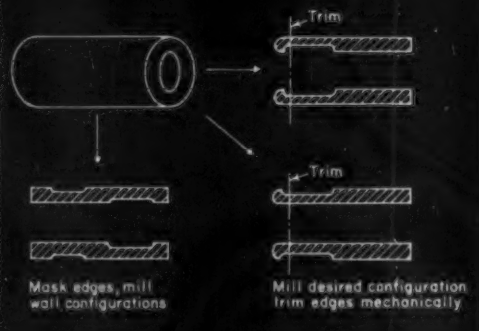

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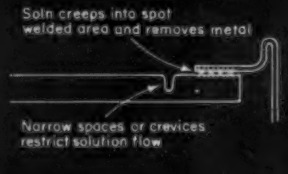

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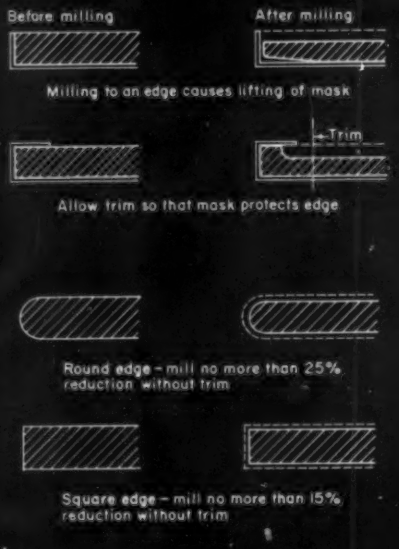

Before milling
After milling
Milling to an edge causes lifting of mask
Trim
Allow trim so that mask protects edge
Round edge – mill no more than 25% reduction without trim
Square edge – mill no more than 15% reduction without trim

11

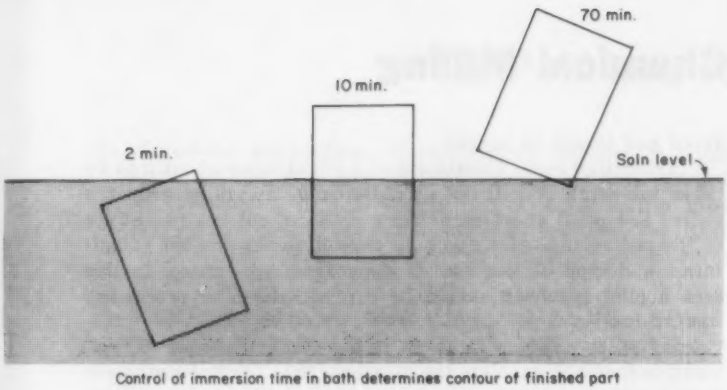
How to get nonuniform metal removal

Although chemical milling is based on a uniform rate of metal removal, it can also be used where nonuniform metal removal is desired. Tapers, for example, are produced by removing the work from a processing bath at a calculated rate. Direction and rate of removal determine the shape of the taper, as seen in the accompanying drawing.

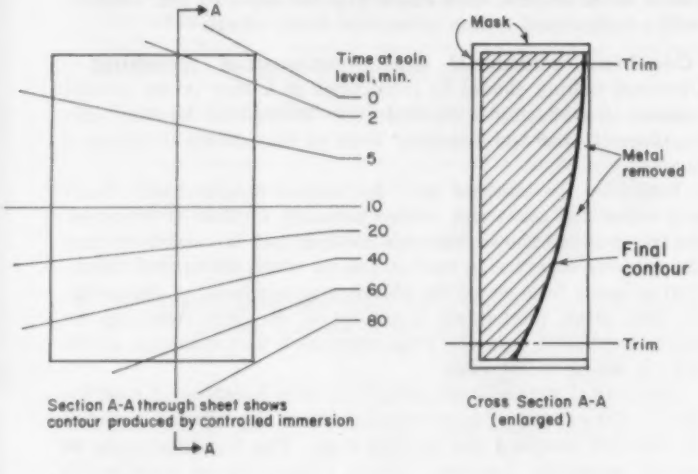
Complex tapers are produced by precalculated removal rates and simultaneous rotation of the part; or by repeated immersion and removal. Visualization of metal removal will establish the shape of the part that can be produced. It is only necessary to keep in mind that total metal removal at any point is a direct function of immersion time, and that rate of metal removal is a controllable constant.

Complex shapes can be produced by multiple tapering and step milling sequences. Although the process is costly—both removing the mask by steps and monitoring of progressive removal are time-consuming—production of a similar shape by mechanical means may be prohibitively expensive.

Since the process can be visualized, calculating the number of steps and time in the bath is relatively straightforward. In preliminary designs, immersion times are estimated by drawing a number of straight "solution level lines" across the design layout. Withdrawal and step sequences, and the man-hours required, can be determined for the most complex shapes.



Control of immersion time in bath determines contour of finished part



For contoured parts, visualize removal rate.

COMING NEXT—Two big issues for May and June are in the works. In May, in addition to the usual bill of fare, you will see the winning entries in our recent Awards Competition. Also, a special show section—previews of both the Design Engineering and the Plastics show. In June: an exclusive report on New Directions in Materials Testing.

Where to Do It: In-Plant or Job Shop?

If the applications for chemical milling are complex and applied to various metals, it is probably best to have the work done by a job shop. If the application involves a large volume of simple parts, with few variations, then in-plant processing can be considered.

Costs vary according to the application. While the approximate cost of chemicals, including make-up control and disposal, is about $0.70 per cu in. of metal removed, total processing costs raise this figure to $2.80 per cu in. A complex chemical milling operation can easily cost $8 per cu in. of metal removed.

The chemical milling process is patented by North American Aviation Corp. Licenses are granted by Turco Products, Inc., Terminal Annex 2649, 6110 S. Central Ave., Los Angeles 54, Calif.

Chemical milling was first described in the Oct '54 issue of this magazine by North American's Manuel C. Sanz ("'Machining' Aluminum by Etching," *Materials & Methods*, Vol. 40, pp 89-93).

M/DE Special Report
No. **182**
April, 1961

Solid propellant rocket engine uses 7178-T6 for nozzle.

Aluminum Co. of America

High Strength Aluminum Alloys:

Where They Stand Now

by Donald Peckner, *Associate Editor, Materials in Design Engineering*

The high strength wrought aluminum alloys were developed over the period beginning in 1928. Alloys 2014 and 2024 were introduced then, and later developments culminated in X2020 in 1957. In spite of the long period of availability, it has been estimated that only 10% of the aluminum alloy production in this country falls into the high strength category. However, such alloys have long been vital in aircraft construction and, more recently, have begun to become significant in a number of non-aircraft applications, such as truck trailers, shotguns and fishing poles. This article will briefly discuss the characteristics of these alloys, the major difficulties encountered in their use, and how these difficulties may be overcome.

■ The term "high strength" has many meanings, but for the purpose of this article the limiting factor is the ability to develop a minimum tensile strength of 60,000 psi. Only two alloy groups fall within the limits of this article. They are the 2000 and 7000 series, which can be generally described as follows:

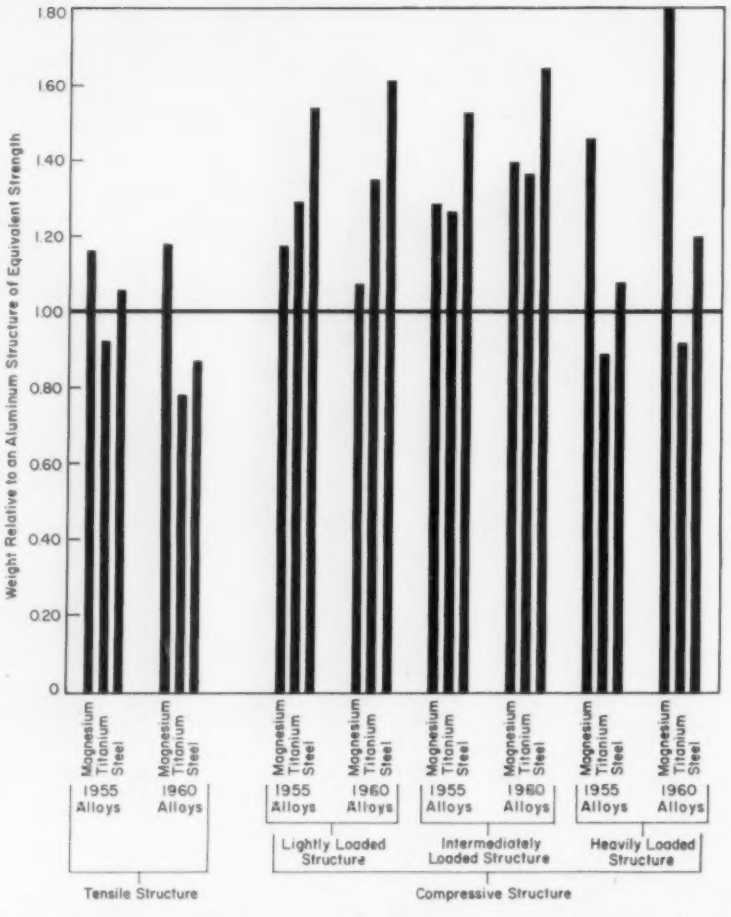
2000 series—The principal alloying element in this group is copper. Solution treatment is needed to obtain optimum properties. In the heat treated condition, mechanical properties are similar to, and sometimes exceed, those of mild steel. Artificial aging can be used to increase yield strength, but it reduces elongation. Tensile strength is not greatly affected by aging.

Relative to other aluminum alloys, corrosion resistance is lower, and the alloys are subject to both intergranular and stress corro-

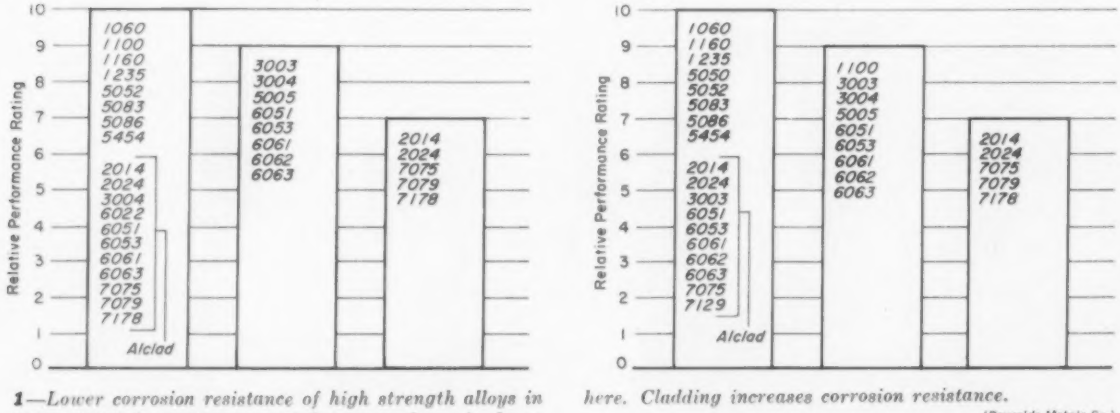
TABLE 1—NOMINAL COMPOSITION OF HIGH STRENGTH ALLOYS (%)[a]

Alloy ↓	Cu	Si	Mn	Mg	Zn	Cr
2014	4.4	0.8	0.8	0.4	—	—
X2020[b]	4.5	—	0.5	—	—	—
2024	4.5	—	0.6	1.5	—	—
7075	1.6	—	—	2.5	5.6	0.3
7079	0.6	—	0.2	3.3	4.3	0.2
7178	2.0	—	—	2.7	6.8	0.3

[a]Remainder is aluminum and normal impurities.
[b]Also contains 1.3% Li, 0.25% Cd.
Source: Aluminum Co. of America, MIL-A-8882 (ASG).



***2**—Weights of magnesium, steel and titanium structures relative to aluminum are compared on basis of alloys available in 1955 and 1960. Titanium and steel can compete on a weight basis in tensile structures. But the combination of low weight and high compressive properties gives aluminum the edge in compressive structures.* (Boeing Airplane Co.)



***1**—Lower corrosion resistance of high strength alloys in industrial (left) and marine (right) atmospheres is shown here. Cladding increases corrosion resistance.* (Reynolds Metals Co.)

sion. The alloys are therefore used, in many instances, with a cladding of high purity aluminum to provide galvanic protection. Cladding reduces mechanical properties but greatly increases corrosion resistance.

7000 series—The major alloying element in this group is zinc, with magnesium the second major addition. Other elements are also added. At the present stage of development, the 7000 series alloys offer the engineer the highest mechanical properties available in aluminum alloys.

Table 1 gives the compositions of the alloys that will be discussed, and Fig 1 shows their corrosion resistance relative to other aluminum alloys in both an industrial and a marine atmosphere.

Pros and cons: a summary

In preparation for this article many industries were surveyed to obtain the users' point of view. Here is a composite view of the favorable and unfavorable characteristics of the high strength aluminum alloys:

▸ *Pro*—

1. High strength-to-weight ratio. Fig 2 shows it graphically in terms of the alloys available in 1955 and in 1960. Fig 3 shows how this ratio is expected to increase for aluminum and four other materials. Fig 4 compares the yield and tensile strengths of two high strength aluminum alloys, 2024-T6 and 7075-T6, with those of other materials.
2. Machinability is excellent.
3. The alloys are nonmagnetic.
4. Handling procedures are not as critical as for other aluminum alloys because of the greater strength and hardness.
5. The alloys are widely available as forgings, extrusions, sheet, etc.
6. They can be extruded to the exact shape desired to obtain a required section modulus.

▸ *Con*—

1. The alloys, especially 7075, 7079 and 7178, are susceptible to stress corrosion cracking.
2. High residual stresses are encountered in heavier sections after solution treating and artificial aging and must be removed by stretching.
3. The alloys generally are notch sensitive, and cracks propagate easily.
4. Probably most important: most of the alloys cannot be fusion welded without severe degradation of mechanical properties.

Section modulus important

Let us use a simple beam as an example to illustrate how aluminum can be substituted for materials having higher mechanical properties.

The beam formula is:

$$s = Mc/I$$

where

s = maximum normal stress parallel to the longitudinal axis of the beam, psi
M = bending moment, in.-lb
c = distance to extreme fiber, in.
I = moment of inertia of the cross sectional area about the neutral axis, in.^{4}

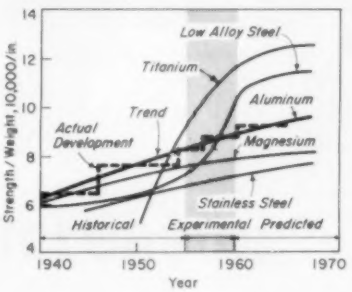
This well known formula determines the maximum tensile and compressive stresses that occur in the outermost fibers of a loaded beam.

Many current designs—aircraft, missiles, and airborne ordnance equipment such as tanks, personnel carriers, etc.—are centered around maximum performance with minimum weight. Table 2 is a composite of design elements for steel and aluminum components of equivalent size. Although the weight of the aluminum section is significantly lower, the section modulus, I, remains the same, as would be expected. The designer can, however, increase the size of the aluminum section to raise I.

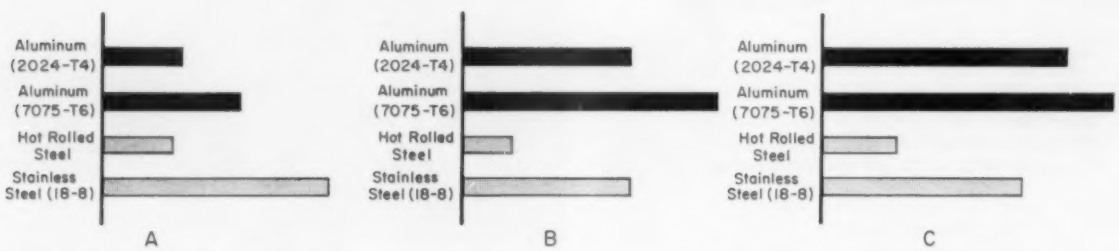
Assuming that bending movement M remains constant, the increase in I outweighs the attendant increase in c so that the net effect is to lower the stress developed in the aluminum member.

Although weight is gained by increasing section size, the component will weigh less than a smaller steel component. Maximum stress is decreased and the mechanical properties of the high

(text continues on p 138)



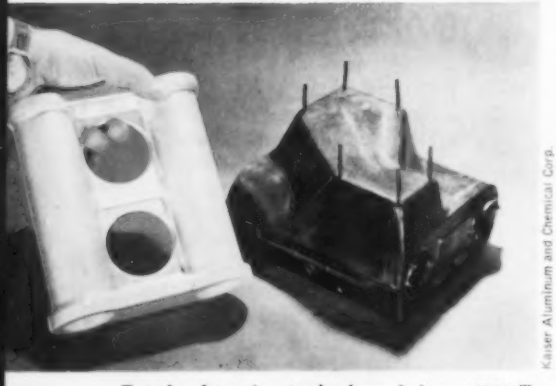
3—*Strength-to-weight ratio of high strength aluminum alloys is continually increasing. However, more rapid increases are predicted for future titanium alloys and low alloy, high strength steels.* (Boeing Airplane Co.)



4—*Relative yield and tensile strengths of two aluminum alloys are compared with those of other structural materials.* **A:** *Yield strength for equal cross sections at room temperature.* **B:** *Yield strength for equal weight at room temperature.* **C:** *Tensile strength for equal weight at room temperature.* (Olin Mathieson Chemical Corp.)

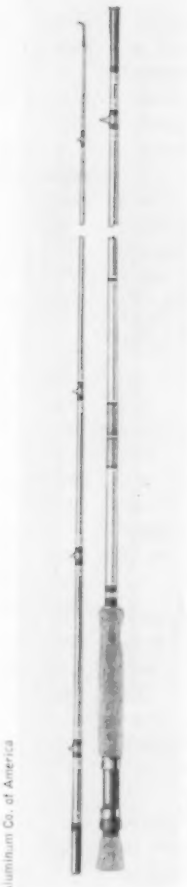
Aluminum Co. of America

Jet propelled hydroplane *uses 2024-T6 and 7075-T6 to increase strength and reduce weight. Riveted construction eliminates the problem of lower strength in welded joints. High strength aluminum offers designer high strength-to-weight ratio and good erosion resistance.*



Kaiser Aluminum and Chemical Corp.

Track shoe *for tank, forged from 2014-T6 alloy, weighs 3.5 lb less than conventional steel shoe. Shoe at right has had rubber tread applied.*



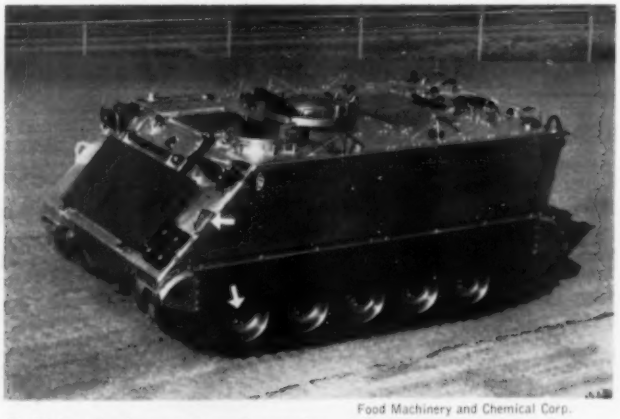
Aluminum Co. of America

Fishing rod *uses 2024-T6 in butt sections to stiffen the rod and provide more control over the flexible glass tip.*

Non-Aircraft

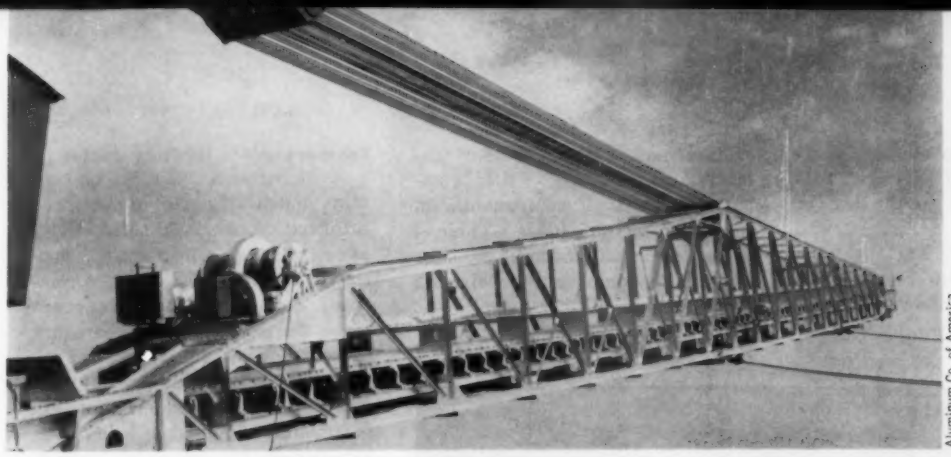
Olin Mathieson Chemical Corp.

Receiver *of new shotgun is made from 7075-T6 because of its light weight, high strength, corrosion resistance and ease of fabrication.*



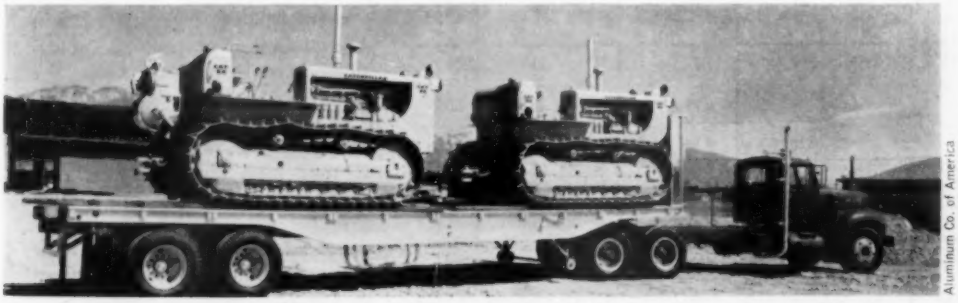
Food Machinery and Chemical Corp.

Full tracked personnel carrier, *M113, uses 7079-T6 for towing eyes (top arrow) and 2014-T6 for bogie wheels (lower arrow). Aluminum was substituted for steel.*



Aluminum Co. of America

Boom *of Great Lakes vessel,* J. R. Sensibar, *was changed from steel to aluminum in modernization program. The new 256-ft long boom is made with 2014-T6 side trusses. It is 60 ft longer and 25 tons lighter than its steel predecessor. Riveted construction maintains strength of alloy.*

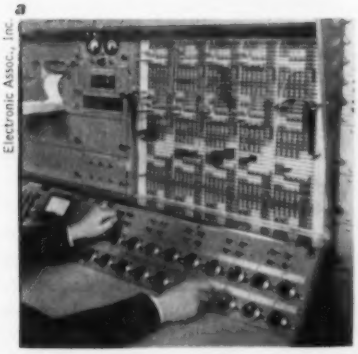


Aluminum Co. of America

Flatbed trailer *40 ft long uses 2014-T6 extrusions for structural side beams. Load carrying ability is indicated by the tractor cargo.*

Uses Are Increasing

a

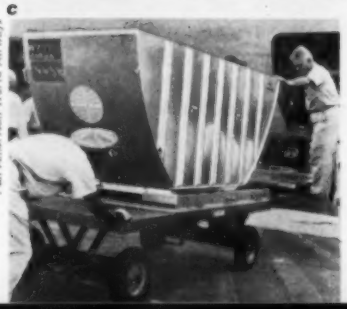


Electronic Assoc., Inc.

b

Aluminum Co. of America

c



Pan American World Airways

d

Head Ski Co.

a *Pre-patch panel for analog computer is fabricated from 2024-T4. The alloy's high strength minimizes warpage during handling and fabricating. Wear in plugholes is also reduced to a minimum.* ***b*** *Drawer slides that are self-aligning are fabricated from 2024-T4 extrusions. Aluminum is used because of its high strength-to-weight ratio.* ***c*** *Cargo containers are made from riveted 2024-T4. Each container weighs 170 lb, holds 1500 lb of cargo. They are produced by Lockheed Special Products to Pan American World Airways specifications.* ***d*** *Ski poles are made from 7000 series alloy tubing for greater strength. Skis (not shown) are fabricated from high strength aluminum laminated over a plywood core.*

strength aluminum alloys become feasible design parameters. This reasoning, applied to the use of extruded sections in aircraft and tanks, helps to explain the wide use of aluminum in these areas.

Table 3 shows how size and section modulus increase for aluminum components when compared with steel components on an equal weight basis. Table 4 presents size and modulus data for aluminum components weighing about half as much as steel.

TABLE 2—SECTION MODULUS AND WEIGHT FOR EQUAL SIZE

Component	Size, in.	Thk, in.	Aluminum		Steel	
			Wt, lb/ft	I, in.⁴	Wt, lb/ft	I, in.⁴
Wide Flange Section	10 × 5¾	0.240	7.3	106.74	21	106.3
I-Beam	7 × 3⅝	0.250	5.27	36.69	15.3	36.2
Angle	4 × 4	0.250	2.28	2.94	6.6	3.0
		0.312	2.83	3.61	8.2	3.7
		0.375	3.38	4.26	9.8	4.4
Channel	3 × 1½	0.356	2.07	2.07	6.0	2.1

Source: *Alcoa Structural Handbook; Steel Construction Manual.*

TABLE 3—SECTION MODULUS AND SIZE FOR EQUAL WEIGHT

Component	Weight, lb/ft	Aluminum			Steel		
		Size, in.	Thk, in.	I, in.⁴	Size, in.	Thk, in.	I, in.⁴
I-Beam	17.25	12 × 5½	0.687	304.84	6 × 3⅛	0.230	21.8
Angle	0.80	1¼ × 1¼	0.250	0.199	1 × 1	0.125	0.02
	9.8	8 × 6	0.625	53.57	3½ × 3½	0.438	3.3
Channel	6.0	7 × 2½	0.524	30.25	3 × 1½	0.356	2.1

Source: *Alcoa Structural Handbook; Steel Construction Manual.*

TABLE 4—SECTION MODULUS AND SIZE WHERE ALUMINUM APPROXIMATELY HALF THE WEIGHT OF STEEL

Component	Weight, lb/ft		Aluminum			Steel		
	Steel	Aluminum	Size, in.	Thk, in.	I, in.⁴	Size, in.	Thk, in.	I, in.⁴
I-Beam	17.25	8.76	10 × 4½	0.310	123.39	6 × 3⅛	0.465	26.0
Channel	13.0	6.48	8 × 2½	0.487	43.96	6 × 2	0.437	17.3
	25.0	12.10	12 × 3	0.632	179.65	10 × 2⅛	0.526	90.7
Angle	6.6	3.35	5 × 3	0.375	7.15	5 × 3	0.250	5.1
	18.5	9.14	8 × 8	0.50	47.74	4 × 4	0.75	7.7
	16.8	8.35	6 × 6	0.625	23.64	5 × 3½	0.625	12.0
Wide Flange Section	24	12.99	8 × 8	0.5	121.31	8 × 6½	0.245	82.5

Source: *Alcoa Structural Handbook; Steel Construction Manual.*

Temperature a limiting factor

As shown in Table 5, which contains much hitherto unpublished information, the 7000 series alloys have greater temperature sensitivity than the 2000 series. A relatively new alloy, X2020, appears to be more stable as temperature increases than any of the alloys formerly used. At the present time X2020 is still considered an experimental alloy and is being used extensively by only one aircraft company. Its properties, however, are of interest to the designer. Stability of mechanical properties at 250 F has been determined by the Naval Air Material Center, and it is clear that long-time exposure at 250 F does not result in degradation of properties. Table 6 summarizes the results of the study.

Fig 5 shows how exposure at 300 F affects the yield strength of four high strength aluminum alloys, and Fig 6 presents similar data for exposure at 600 F. Decrease of the modulus of elasticity as temperature increases is shown in Fig 7.

Section size affects strength

As with plain carbon steels, heat treated alloys 7075, 7079 and 7178 show a definite section size effect when solution treated and aged. The 2000 series alloys do not exhibit this phenomenon. Both 7075 and 7178 are limited in section thickness to a maximum of 3 in. when high mechanical properties are needed on a reproducible basis. In heavier sections desired mechanical properties are obtained by using alloy 7079 in thicknesses up to 6 in.

Effect of section size on mechanical properties is shown in Table 7.

Stress corrosion effects

The alloys being discussed in this article are heat treatable and, as a consequence, are subject to both intercrystalline and stress corrosion cracking when the aging cycle is not properly handled. If aging temperature is slightly low or time too short, precipitates that form at the grain boundaries may be anodic relative to the material within the grains. Under

these circumstances intergranular attack may occur. Such attack, when combined with service stresses, may lead to stress corrosion cracking.

Time at aging temperature affects the strength of a material that has been stressed in a corroding medium. In the case illustrated in Fig 8, specimens were bent into an arc to stress the fibers to 80% of the yield strength while they were immersed in a corrosive solution. The specimens were then tested in tension, loss in strength being adopted as a criterion of damage. A disproportionately high increase in loss of strength occurred when the alloy was improperly aged. It is apparent from Fig 8 that loss of strength caused by stress corrosion is considerably lower when alloy 2024 has been aged to achieve maximum mechanical properties.

The National Bureau of Standards has investigated the susceptibility to stress corrosion of 7075, 7079 and 7178 in various forms.

The most serious aspect of the problem, both for the 2000 and 7000 series alloys, is the drastic reduction in load-carrying ability in the short transverse, or thickness, direction. The resistance of the alloys in the T6 temper to stress corrosion cracking in the short transverse direction, at stresses equivalent to 75% of the yield strength in that direction, is so low that use at this stress level is not recommended. In the other transverse direction, the maximum allowable stress of 75% of the yield strength can be applied with discretion. In the longitudinal direction, stresses up to 75% of the yield strength can be applied without danger of cracking or premature failure.

Susceptibility to stress corrosion cracking means that the designer should avoid such practices as press or shrink fits. Straightening and assembly operations that result in residual surface tensile stresses should also be avoided whenever possible.

TABLE 5—ELEVATED TEMPERATURE AFFECTS PROPERTIES OF HIGH STRENGTH ALUMINUM ALLOYS

Temperature, F ➡	75	212	300	400
2014-T6				
Ten Str, 1000 psi	70	64	40	16
Yld Str, 1000 psi	60	58	35	13
Elong, %	13	14	15	35
X2020-T6				
Ten Str, 1000 psi	84	80	58	28
Yld Str, 1000 psi	77	74	55	23
Elong, %[b]	7	9	15	24
2024-T4				
Ten Str, 1000 psi	68	64	45	27
Yld Str, 1000 psi	47	47	36	20
Elong, %	19	19	17	27
7075-T6				
Ten Str, 1000 psi	83	70	31	16
Yld Str, 1000 psi	73	65	27	13
Elong, %	11	14	30	55
7079-T6				
Ten Str, 1000 psi	78	67	33	16
Yld Str, 1000 psi	68	60	28	13
Elong, %	14	18	37	60
7178-T6[c]				
Ten Str, 1000 psi	88	80	32	16
Yld Str, 1000 psi	78	72	28	13
Elong, %[d]	11	14	30	55

[a]Based on 10,000-hr exposure.
[b]% of 4d, ½-in. dia specimen.
[c]Based on 1000-hr exposure.
[d]½-in. dia specimen.
Source: Aluminum Co. of America.

TABLE 6—X2020 MAINTAINS PROPERTIES AFTER LONG TIME AT 250 F[a]

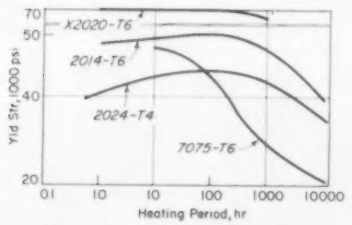
Exposure Time, hr	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %
0[b]	86	79	6.0
500	86.6	80.6	2.95
1000	87.4	81.4	2.33
3000	85.9	78.5	3.04

[a]Average of three tests made at room temp.
[b]Aluminum Co. of America data.
Source: Naval Air Material Center Rpt. NAMC-AML-AE-4195.

TABLE 7—SECTION SIZE AFFECTS PROPERTIES OF SHEET, PLATE

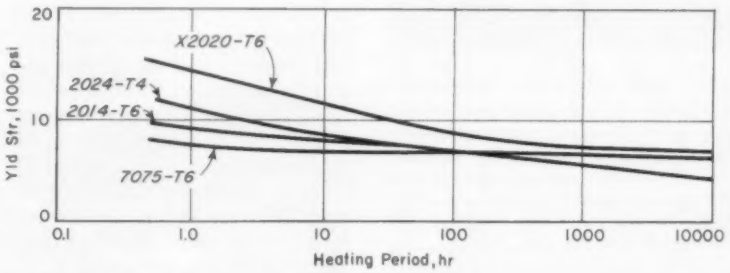
Thickness, in. ➡	Ten Str, 1000 psi[a]	Yld Str, 1000 psi[a]	Elong, in 2 in., %[a]
2014-T6			
0.250-1.50	67	59	4
1.501-2.00	65	59	3
2.001-3.00	63	57	2
2024-T6			
0.012-0.499	64	50	5
Over 0.499	63	50	5
7075-T6			
0.015-0.039	76	65	7
0.040-0.499	77	66	8
0.500-1.00	77	66	6
1.001-2.00	77	66	4
2.001-2.50	73	62	3
2.501-3.00	70	60	3
7079-T6			
0.250-1.00	74	65	8
1.001-1.50	73	64	8
1.501-2.00	73	64	7
2.001-2.50	73	63	6
2.501-3.00	70	62	6
3.001-4.00	70	60	5
4.001-4.500	68	58	5
7178-T6			
0.015-0.044	83	72	7
0.045-0.499	84	73	8
0.500-1.00	84	73	6
1.001-1.50	84	73	4
1.501-2.00	80	70	3

[a]Minimum.



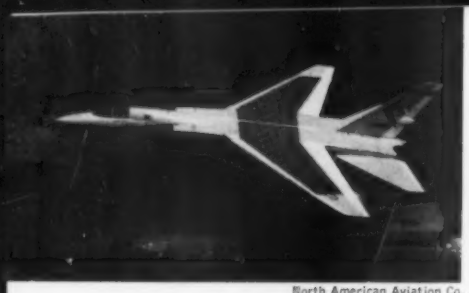
5—*Yield strength of aluminum is affected by time held at 300 F.*

(Boeing Airplane Co.)



6—*Yield strength decreases rapidly at 600 F.*

(Boeing Airplane Co.)



North American Aviation Co.

Wing skin *on A3J uses X2020-T6 alloy (shaded area) for high efficiency.*

terials, the aluminum alloys must be carefully handled. Here is a composite summary of recommendations by aircraft companies, the principal users:

Forming is not too much of a problem. If parts are fabricated in the "O" condition, you should expect distortion after solution treating. Restriking the component may be necessary to maintain critical dimensions. To minimize distortion, alloys can be formed as solution treated if they are refrigerated before forming to prevent natural aging.

2014: Preferred for high strength mechanical forged fittings. Also, for high strength extrusions that require no heat treatment after forming, since this alloy is less expensive and more easily extruded than either 2024 or 7075. Forming can be done cold or at 375 F. Minimum recommended section thickness: 0.125 in. Because of weight and strength considerations, 2014 has been largely superseded by 2024 and 7075.

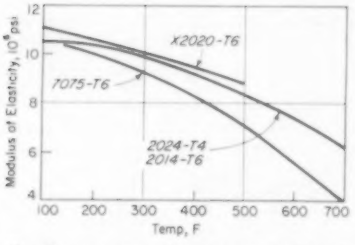
X2020: Can be formed in the solution heat treated condition because of its long natural aging period. Unlike 2024 and 7075 which age naturally in one to three days, X2020 does not appreciably age naturally for almost one year. Crack propagation problems prevent cold forming in the aged condition.

2024: Used largely as extrusions where size and forming limitations prevent use of 2014-T6. Severe forming requires starting with 2024-O (annealed) material and heat treating to the desired temper after forming. In bar form, 2024 can be used when the higher strength of 7075 is not required. Sheet can be formed hot at 375 F.

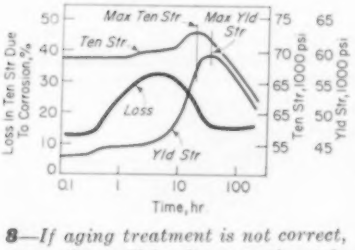
7075: As forgings, used only when 2014 does not offer high enough tensile and compressive properties and when weight is a consideration. Poor heat treatment response limits maximum section size to 3 in. Extrusions are used when strength requirements cannot be met with the less expensive 2014 or 2024. Applications requiring transverse loading are limited by poor ductility in the transverse direction. Severe warpage is encountered after solution treating and quenching, and must be controlled. Sheet is usually specified when strength requirements exceed the properties available with 2024.

7079: Ordinarily used only for forgings when section size exceeds 3 in. It is more desirable than 7075-T6 because of higher ductility and strength, particularly in transverse sections over 2 in. thick.

7178: Offers higher allowable compressive properties than all other alloys with the exception of X2020. Severe warpage after solution treating and quenching raises processing costs. The alloy is available as sheet, plate, extrusions, forgings and other mill products.



7—*Temperature has severe effect on modulus of elasticity. Note that X2020-T6 is not as severely affected.* (Boeing Airplane Co.)



8—*If aging treatment is not correct, 2024 alloy will be disproportionately susceptible to stress corrosion attack. Curves are for 2024 alloy aged at 345 F. Tensile tests on material that has been exposed to a corrodent while under stress show that greatest loss of tensile strength occurs when aging does not produce maximum mechanical properties.*

How about welding?

The high strength aluminum alloys can be fusion welded only if the weldment can be heat treated after fabrication is completed. These alloys, as is true of all high strength materials, suffer a severe loss of mechanical properties in the weld and heat affected zone. Unless the weldment can be reheat treated to the T6 condition, you are probably wiser to choose a lower strength weldable grade such as 5083 or 5086. (See M/DE, July '59, p 91 for a detailed discussion of these alloys.)

If fusion welding is not feasible you can consider ultrasonic welding, resistance welding, percussion welding, etc. These methods have been successfully used to join the high strength aluminum alloys with excellent joint efficiencies.

Other techniques available—Mechanical fastening of aluminum components is a standard technique. A newer approach to fastening and joining problems allows the designer to use adhesive bonding to join stressed components that do not exceed 250 F in service.

Acknowledgments

The writer would like to thank C. L. Carlson, Westinghouse Electric Corp., and E. H. Spuhler, Aluminum Co. of America, for their helpful comments concerning this article. The cooperation of the following companies was of material assistance:

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Head Ski Co.
Kaiser Aluminum & Chemical Corp.
Lockheed Aircraft Corp.
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first in silicones

Dow Corning

SILICONE NEWS

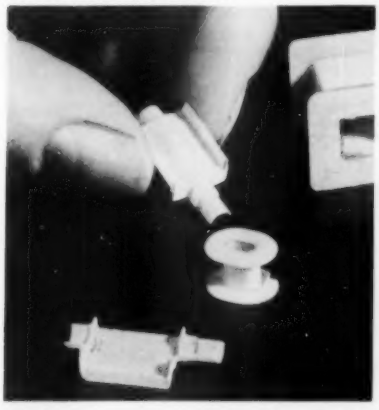
for design and development engineers · No. 82

Silicones Simplify Miniaturization

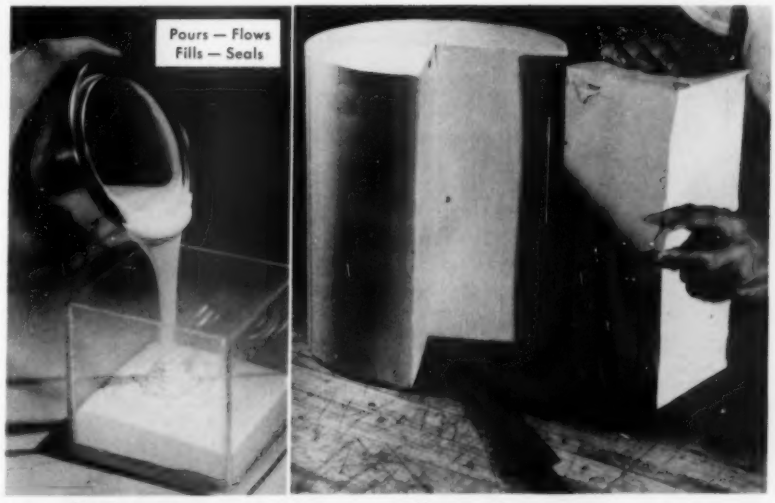
Miniaturization means heat. Heat that has to be dissipated from smaller surface areas. Temperatures go up — and materials like Dow Corning Silicones come into their own!

Take silicone-glass laminates, for example. At high temperatures they have dielectric properties that are superior to those of other laminated materials. In addition, silicone-glass laminates have excellent resistance to ozone, arcing, corona, and fungus attack . . . even the formidable combination of high humidity and high voltage.

Mechanical strength is good — permitting thin, rigid coil bobbin walls, more winding space and better resistance to winding pressure. One-piece laminated coil bobbins, like those shown, are used in continuous operation at 250 C, have been tested at 400 C for 1,000 hours.



These are reasons why the Foster Transformer Company, Cincinnati, Ohio, specifies coil bobbins of silicone-glass laminates made by Silicone Insulation Inc., Bronx, N. Y. These small, sturdy coil bobbins are part of computer *(Cont. Pg. 2)*



Cold Cures In Thick Sections

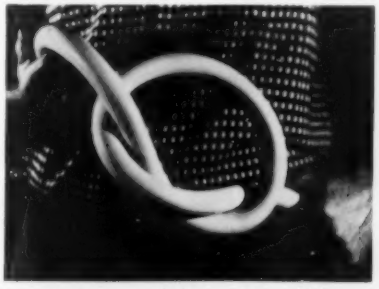
New and available — a free-flowing fluid silicone rubber that vulcanizes in sections of unlimited thickness and at room temperature!

Identified as Silastic® RTV 601, the new rubber cures without heat, pressure or moisture . . . even under totally confined air-tight conditions. All that's required is the addition of a catalyst and 24 hours time to set up into a rubbery solid. Variations in thickness have no significant effect on curing rate and uniformity. Venting during cure is unnecessary because no volatile by-products are produced by the vulcanization reaction.

The handling characteristics and properties of Silastic RTV 601 suggest usefulness in a variety of applications ranging from the making of flexible molds and casting of prototype parts to potting and encapsulating deep or totally enclosed electrical and electronic components. Supplied as a low viscosity fluid rubber, it flows into and around the most intricate designs, completely filling narrow cavities and hairline cracks.

After vulcanizing 24 hours at 77 F, parts or sections made from Silastic RTV 601 can immediately be put into full service at temperatures from —100 to 500 F. Physical and electrical properties are consistent through all dimensions of a section.

Another important feature of this RTV (room-temperature-vulcanizing) silicone rubber is control over set-up time. Under normal conditions, Silastic RTV 601 will



set up to a tack-free solid within 12 hours after catalyzation. By adjusting the catalyst concentration or the cure temperature, set-up time can be lengthened or reduced as desired — without affecting final properties.

For a sample of new Silastic RTV 601, write to Dow Corning Corporation, Midland, Michigan on your business letterhead. For additional information, circle **No. 241**

See Silicones At Booth 644

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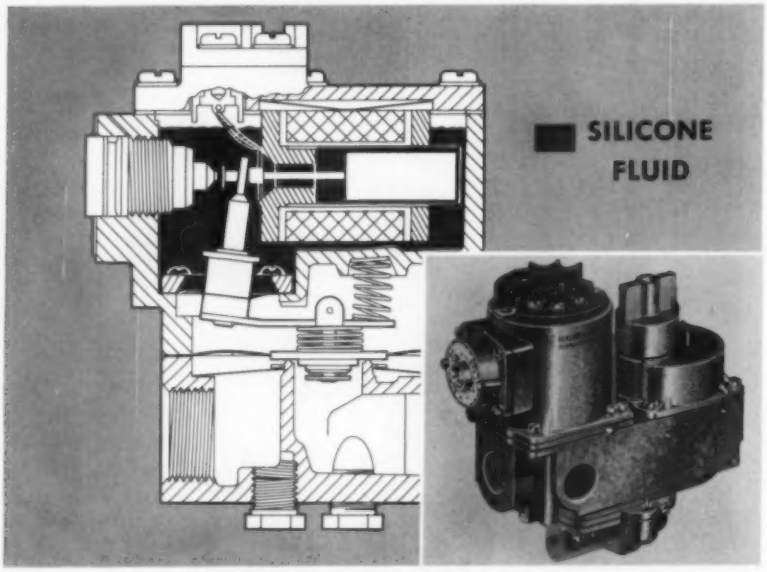


SMOOTHS CONTROLS

Engineers at General Controls Company, Glendale, California, designed their Dial-A-Flow gas valve so that the operating mechanism is immersed in Dow Corning 200 Fluid.

Result: This viscous silicone fluid cushions the snap action of the mechanism and makes it silent. The undesirable pop of gas ignition and noise of plunger impact are eliminated. Wide rangeability of the Dial-A-Flow valve permits heating equipment manufacturers to use just one valve for most of their input requirements.

Job-proved as the ideal fluid damping medium, Dow Corning 200 Fluid doesn't thicken or thin with temperature change . . . assures uniform performance over wide temperature spans. Resistant to oxidation and to breakdown under shear, and characterized by excellent dielectric properties, Dow Corning 200 Fluid increases reliability of performance of a wide variety of industrial and military components and accessories — sensitive motion detectors, accelerometers, instruments and gages; automotive fan drives and torsional vibration dampers; liquid springs; and hydraulic couplings.

For more information about Dow Corning silicone fluids — and how their unusual combination of properties makes design changes possible, circle . . . **No. 242**

SILICONE GLASS *(Cont.)*

power transformers that weigh only 0.85 pounds each . . . that must give dependable service in airborne guidance control systems.

Coil bobbins made of silicone-glass laminates are used by Foster in filter chokes and output transformers as well as in computer power transformers . . . and each of these units is impregnated with Dow Corning silicone varnish to assure reliability of miniaturized designs.

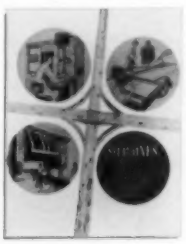
For more information about properties and applications of glass laminates made with Dow Corning Silicones, circle **No. 243**

new literature and technical data on silicones

How to insulate motor coils with self-adhering silicone rubber tape is described step by step in a four-page, illustrated data sheet. Benefits listed include protection of components against hazards of high humidity, vibration, thermal expansion and mechanical shock. **No. 244**

Up-to-the-minute. The new Engineering Guide to the Properties and Applications for Dow Corning Silicone Products is now available. This 16-page brochure contains the most current information on all lines, all forms of silicone products manufactured by Dow Corning for engineering applications. Bring your reference files up-to-date by encircling . . . . . **No. 245**

Silicones for the Automotive Industry is the subject of an eight-page brochure that cites illustrations and descriptions of the many research, engineering, and automotive production applications wherein silicones make possible superior performance. Some of the applications include power plants, braking systems, power transmissions, electrical components, surface protection, lubrication, and many more applications of interest to every design engineer. **No. 246**



Job-proved Dow Corning silicone lubricants help designers solve lubrication problems created by adverse operating conditions. Used on equipment ranging from freezers to core oven conveyors — at temperatures as low as minus 100 F, as high as 500 F. Send for a handy brochure on properties and applications. **No. 247**

Wherever there's a problem — gaskets, seals, O-rings . . . rubber parts fabricated of Silastic, the Dow Corning silicone rubber, stay rubbery in spite of heat, cold, compression, weathering or ozone, moisture or steam, oils, fuels, or chemicals that often cause problems. This six-page, illustrated brochure cites how these problems are overcome by the use of Silastic . . . to increase the life and reliability of scores of units while reducing maintenance costs and frequently simplifying design. **No. 248**

Dow Corning Corporation, Dept. 5316, Midland, Michigan

Please send me: 241 242 243 244 245 246 247 248

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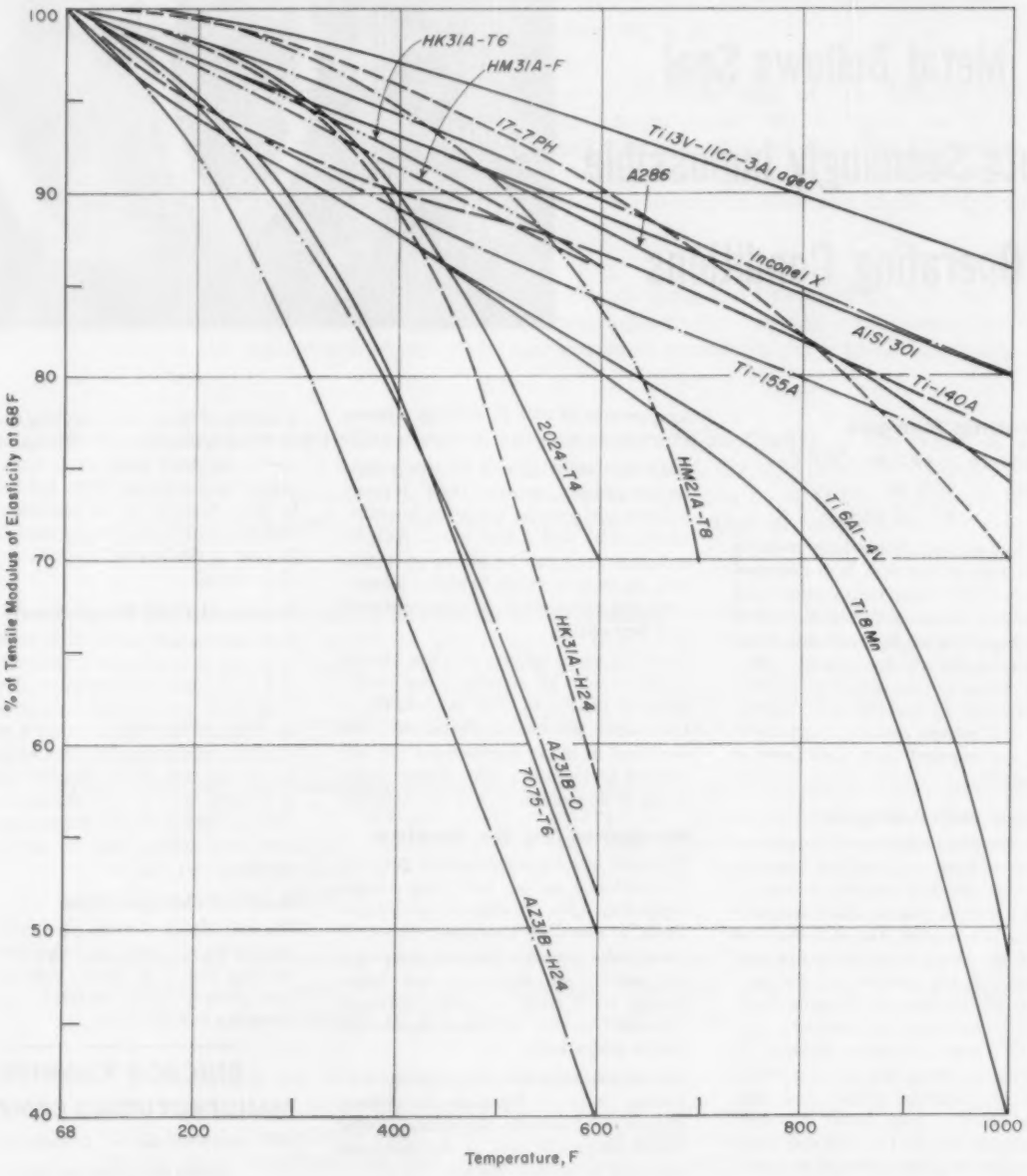
FILE FACTS

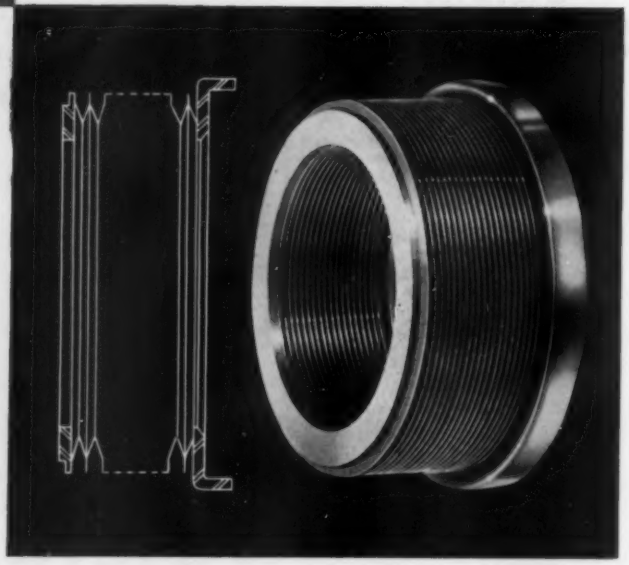
How Temperature Affects the Tensile Modulus of Elasticity of 16 Alloys



Courtesy: Brooks & Perkins, Inc.

C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

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A new rigid vinyl resin—polyvinyl dichloride—will be put into commercial production the first of next month at the Louisville, Ky. plant of B. F. Goodrich Chemical Co. The plant's capacity has not been disclosed. The new vinyl resin, called Hi-Temp Geon, is said to offer continuous heat resistance in the 180-200 F temperature range. It was introduced last summer (M/DE, July '60, p 9).

Use of pearlitic malleable iron in 1960 reached a new high of over 190,000 tons, according to the Malleable Founders Society. A big reason for increased use of the metal has been its acceptance as the crankshaft material on the 1961 Oldsmobile F-85, Buick Special and Pontiac Tempest. Malleable industry spokesmen expect pearlitic malleable consumption to jump to 235,000 tons in 1965 and to 285,000 tons in 1970.

A new supplier of polyethylene resins is Rexall Drug and Chemical Co. At present, the company says it will market the thermoplastic under a resale arrangement until its own 120 million-pound-per-year plant comes on stream in early 1962. Tradename is Elrex.

More electron-beam-refined refractory metals are available as the result of a new furnace now in operation at the Richmond, Calif. plant of Stauffer Metals Co. The 300-kw unit is said to be the largest such furnace ever built. It brings total U. S. capacity for production of electron-beam-refined refractory metals to over 200 tons per year.

Prices for a new series of thermosetting plastics resins called Buton have been announced recently by Enjay Chemical Co., Div. of Humble Oil & Refining Co. Tank car prices are 35¢ per lb for the 100% solids resin and 24¢ per lb for the 50% solids resin. The new resins, based on butadiene-styrene polymers, are designed for use in decorative and protective coatings (M/DE, Jan '61, p 152).

Price cuts on copper-clad steel have been announced by Superior Steel Div. of Copperweld Steel Co.—the second price change for this supplier in recent months (M/DE, Dec '60, p 25). Cold rolled steel strip clad on both sides with copper or brass is $43 per 100 lb, down 40¢ from the previous price. Steel strip clad on one side with copper is $36.10 per 100 lb, down 25¢.

Production of reinforced plastics is expected to reach 500 million pounds in the next five years, according to Owens-Corning Fiberglas Corp. Some of the fastest growing applications are in the transportation industry.

Price reductions on ABS plastics compounds (acrylonitrile-butadiene-styrene) have been announced by Naugatuck Chemical Co., Div. of U. S. Rubber Co. Biggest cut was for Kralastic HTHT, a compound with good heat resistance. New price is 54¢ per lb in truckload lots, down 6¢ per lb. Price cuts for other Kralastic compounds amount to 2¢ per lb.

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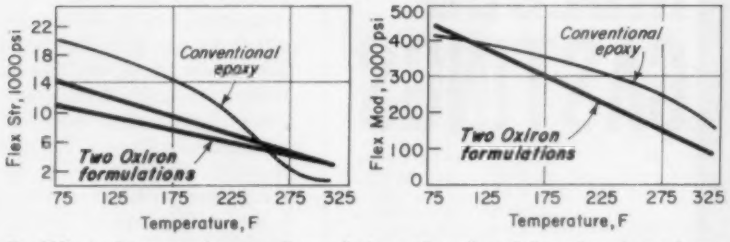
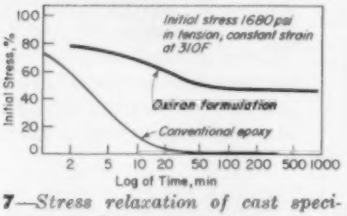
(cont'd from p 21)



6—*Effect of temperature on flexural strength and modulus of cast specimens of a conventional epoxy formulation and two Oxiron formulations.*

formulation at 310 F. The curves show decay in stress when tested at a constant strain imposed by initial loading of 1680 psi.



7—*Stress relaxation of cast specimens of Oxiron vs a conventional epoxy formulation.*

TABLE 2—TYPICAL PROPERTIES OF REINFORCED OXIRON LAMINATES (14 Ply, ⅛ in., 181 Cloth)

Form →	Pregreg[a]	Wet Lay-Up[b]
Flex Str, 1000 psi		
77 F	80.5	76.4
160 F	—	71.7
Flex Mod of Elast (77 F), 10^6 psi	3.8	3.3
Ten Str, 1000 psi	66.3	51.3
Ten Mod of Elast, 10^6 psi	5.0	3.6
Edgewise Compr Str, 1000 psi		
77 F	55.0	53.9
160 F	—	57.8
Barcol Hardness	90	92

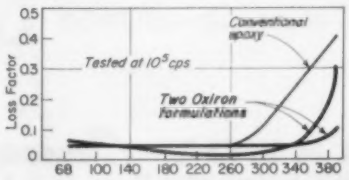
[a]Volan A finish. Cure: 30 min at 310 F, 1000 psi, followed by 4-hr postcure at 310 F.
[b]Type 172 finish. Cure: 45 min at 230 F, 150 psi, followed by 4-hr postcure at 310 F.
Source: Food Machinery & Chemical Corp.

Fig 8 shows improvement in retention of a low loss factor at temperatures above 280 F. Both the Oxiron materials and the conventional epoxy were formulated with the same curing system.

Reinforced specimens—The Oxirons are reported to be well suited to either wet lay-up or dry (prepreg) processing. Table 2 lists typical properties obtained on laminates produced by both techniques. The data in Table 2 were made available by Food Machinery & Chemical Corp. after the meeting.

Two self-extinguishing resins

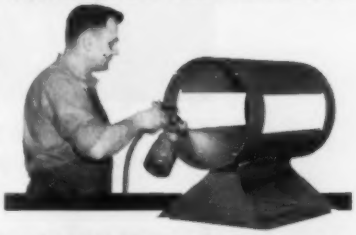
Epoxy—A new epoxy resin, self-extinguishing in 1-5 sec when tested according to ASTM D635, has the additional advantage of being a free-flowing liquid at room temperature. The material, called Epotuf ED-1029, was described by S. N. Ephraim and S. W. Street



8—*Effect of temperature on loss factor of a conventional epoxy and two Oxiron formulations.*

SICON® the original silicone base

heat RESISTANT FINISH protects INSIDE and OUTSIDE of High Temperature Combustion Tube Furnaces



The Hevi-Duty Combustion Tube Furnace offers excellent high temperature uniformity—for extended periods of time with minimal heat loss. Sicon, in an attractive metallic green, protects both *inside* and *outside* of steel shell. It does not peel, flake or lose original color—even at temperatures approaching the 1000°F. range. Sicon is the *proved* protective coating for all hot surfaces . . . from manifolds to missiles. Write for latest brochure *now*. Address Dept. D-1.

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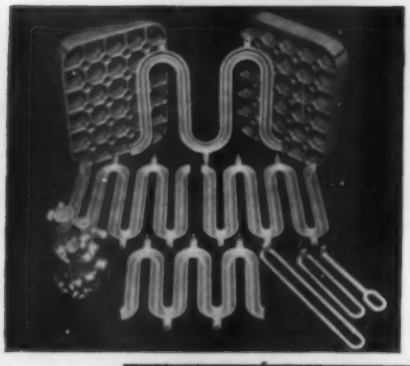
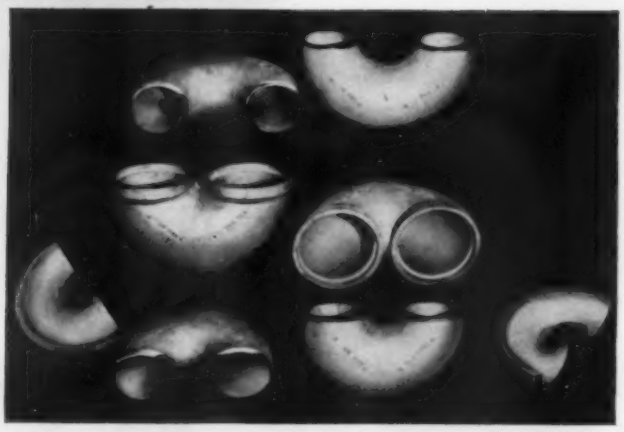
SHELL MOLDED CASTINGS





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of Reichhold Chemicals, Inc. (SPI).

According to the authors, previously available self-extinguishing epoxies have had important limitations: the self-extinguishing characteristics have been obtained either by use of halogenated acid anhydrides, thus limiting formulations to anyhydride-cured systems, or by use of tetrachloro or tetrabromobisphenol A, resulting in resins that are solids at room temperature and have a tendency to crystallize out of certain solutions.

The new epoxy is a liquid with a viscosity of 7500 poises at room temperature and has no tendency to crystallize.

Polystyrenes — Self-extinguishing injection molding and extrusion grades of polystyrene materials that qualify under Underwriter or building code requirements are now commercially available as general purpose, medium, or high impact types. The materials are self-extinguishing in 5 sec when specimens greater than

All glass-epoxy rotor blade *newly developed for Kaman Aircraft Corp.'s H-43 helicopter has improved fatigue resistance and provides major savings in manufacturing and maintenance costs. Reports after the first flight indicated the blade operated as well as conventional blades. (SPI)*

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A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

NO PLACE FOR AN ACROPHOBE

When first we read of the seven who are eager to blaze a route to the stars, we pondered what we thought of as man's inborn fear of great heights.

Now we learn that the first of the astronauts will have a window in his capsule, that he will peer *down* at the spinning earth and *out* at the wheeling stars.

We are producing these unique, space-going viewports for McDonnell Aircraft Corporation, prime contractor for the National Aeronautics and Space Administration's Project Mercury capsule.

The window is an excellent piece of engineering. Not just because we made it, but because it *has* to be.

It will take the slams and whams, the blistering heat, and the embrittling cold of blast-off, orbitation, re-entry, and a soak in the briny. All during this it must remain transparent, intact, and sealed tight.

There are four panes to the window. The outer two are VYCOR® 96% silica glass. The inner two are aluminosilicate glass specially tempered to phenomenal strength.

Each pane is ground and polished to the precision finish of a telescope mirror. The outermost panel curves to the contour of the capsule, so it trapezoids from an 11″ base to a 7½″ top along a 21″ height.

The glasses present a delicate balance of optical qualities, thermal shock resistance, and low weight. The last is vital when you consider that it takes about 100 gm of fuel to orbit 1 gm of payload.

So, remember, when you see the first astronaut smiling quietly, confidently from his capsule, you are looking at him through Corning glass.

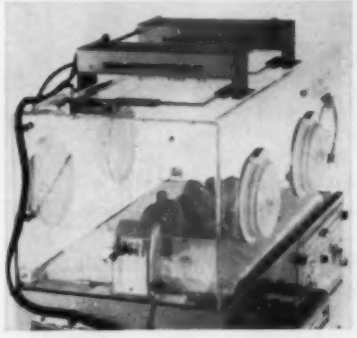
HOW ABOUT A DEGREE IN MEDICAL ENGINEERING?

The mechanics of modern medicine are fast maturing to the point where some engineers are specializing in the building of machines like this Infant Servo-Controller for the Isolette, manufactured by Air-Shields, Inc., Hatboro, Pennsylvania.

This particular machine is used with prematurely born infants who must keep their body temperature at a constant level, but lack a well-developed thermal regulatory device.

You attach a thermistor to the babe's abdomen and let him work as his own thermostat. He automatically requests heat from infrared lamps whenever his skin temperature drops below 97°F. When things are just right again, he switches off the lamps and takes a rest, with the odds for survival more in his favor.

If you've ever tried to unbulb an infrared lamp, you know that it gives off *direct* heat as well as IR energy.

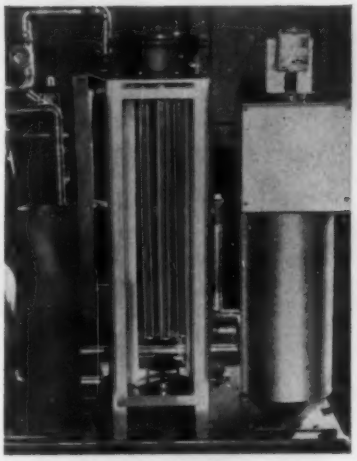


That's why there are two PYREX No. 7740 glass plates sitting on top of the plastic chamber in the picture. You can see them, if you look closely. The PYREX plates are heat resistant and will also dissipate the *direct* thermal output of the lamps. So, the plastic forgets the lamps are there.

As far as the IR energy is concerned, the PYREX plates don't exist either, so practically all the IR gets through to the baby.

The over-all relationship between IR and glass is an odd one. We can give you glass which transmits as much as 92% of the IR or a glass which transmits as little as 8% of the IR.

Happily for our product specialists, there is demand for both situations. We've prepared some bulletins on many of these IR characteristics, a copy of which you may have by sending the coupon.



SOMETIMES GLASS IS SO OBVIOUS

Leafing our way through the 4th Annual Shirt Issue of "Cleaning Laundry World" (April 1960), we took note of an advertisement which concerned a machine which displayed a feature which we consider the soul of genius.

The machine is a dry cleaner manufactured by Detrex Chemical Industries, Inc. The feature is a glass-enclosed filter which keeps the dry-cleaning solvent cycling unpolluted. The soul of genius, to our minds, consists of intelligent manipulation of the obvious . . . in this case, an application of the first known and longest respected of the myriad properties of glass . . . to wit, its *transparency*.

When you locate such a place, it doesn't necessarily take a lot of redesigning of custom fabrication to put glass to work, either. We checked and found that Detrex, for example, simply orders standard 6″ O.D. PYREX brand Heavy Duty Tube for its filter wall.

The result is that the operator of the Detrex Cleaner can watch the filter at work. He can spot trouble while it's still potential, determine its cause exactly should it occur . . . all without any dismantling or shutdown.

Is there anything you're working on that you wish you could watch working? If there is, and you want to put glass to work, you can start by sending the coupon for a copy of Bulletin IZ-1, "Designing with Glass for Industrial, Commercial, and Consumer Applications."

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS, 504 Crystal St., Corning, N. Y.

☐ IR Transmitting Glasses ☐ IR Reflecting Glass ☐ IZ-1

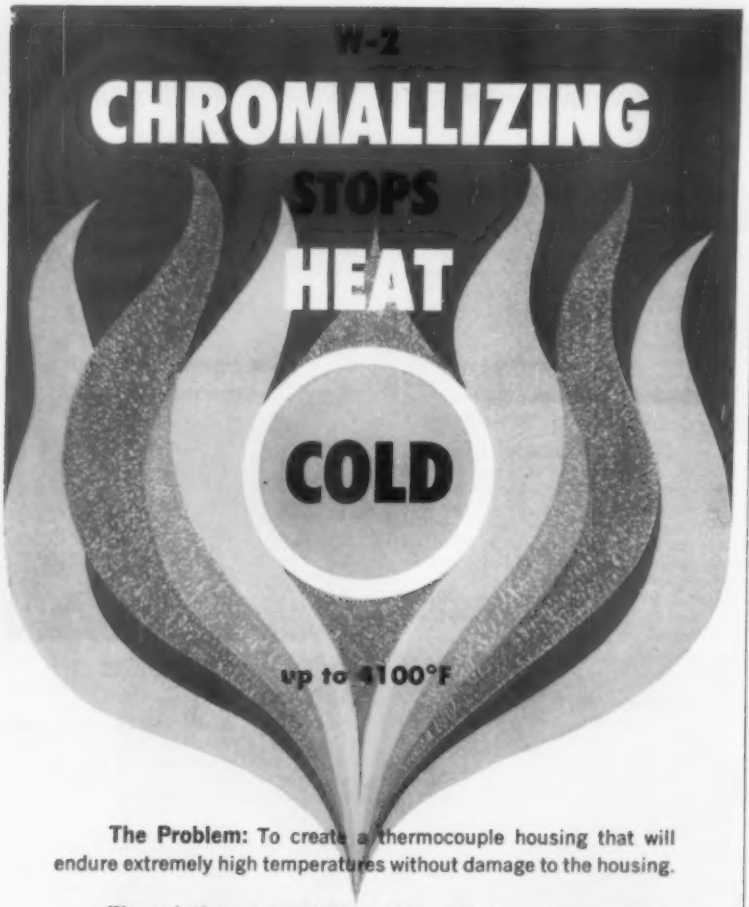
Name..... Title.....

Company.....

Street.....

City..... Zone..... State.....

For more information, turn to Reader Service card, circle No. 352



The Problem: To create a thermocouple housing that will endure extremely high temperatures without damage to the housing.

The solution: A CHROMALLIZED molybdenum thermocouple housing. This housing withstands temperatures up to 4100°F. Other applications are structural parts for re-entry vehicles, high temperature testing grips, and ramjet engine components.

What is Chromallizing?
A proven process for diffusing chromium and other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake. the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

CHROMALLIZING processes are also being used to protect superalloys for jet engine parts and to protect ordinary steel against wear, oxidation and corrosion.

WRITE FOR ILLUSTRATED BULLETIN MC

Chromalloy corporation
169 WESTERN HIGHWAY, WEST NYACK, N.Y.
ELmwood 8-5900
CHROMIZING CORPORATION, LOS ANGELES, CALIFORNIA
PROPELLEX CHEMICAL DIVISION, EDWARDSVILLE, ILLINOIS
Propellents, cartridge actuated devices, explosives and special chemicals.
ELYRIA FOUNDRY DIVISION, ELYRIA, OHIO. Quality gray iron castings.
SINTERCAST DIVISION, YONKERS, N. Y. Machinable carbides & nuclear materials.

For more information, turn to Reader Service card, circle No. 353

20 mils thick are tested by ASTM D635. The materials were described by J. C. Misko and C. F. Martino, Union Carbide Plastics Co. (SPE).

In comparison with conventional grades of polystyrene, the new materials are somewhat lower in strength and rigidity, and somewhat higher in density (specific gravity of 1.2 vs 1.05). Dielectric properties are not quite as good as those of conventional polystyrenes.

Data on new fluorocarbon

Additional data on chemical resistance, long term strength, and fabrication of the relatively new fluorocarbon plastic, polyvinylidene fluoride, designated RC 2525 (see M/DE, May '60, p 9), were given by W. S. Barnhart, R. A. Ferren, H. Iserson, and others of Pennsalt Chemicals Corp. (SPE).

Table 3 shows selected data on effects of chemicals on 5-mil films. Retention of 5000 psi tensile

TABLE 3—CHEMICAL RESISTANCE OF RC 2525 FLUOROCARBON[a] (30 Days at 122 F)

Reagent	Retained Ten Str, psi
Control (not exposed)	7200
ACIDS	
Acetic, Glacial	5400
Hydrochloric, 35%	7100
Nitric, Fuming	6300
Sulfuric, 95%	7100
Sulfuric, Fuming	Degraded
BASES	
Ammonium Hydroxide	7200
Aniline	5400
n-Butylamine	Degraded
Diethylamine	5500
Sodium Hydroxide, 50%	7200
SOLVENTS	
Acetone	Partially dissolves
Benzene	5600
Dimethylacetamide	Dissolves
Ethylacetate	500
Iso-octane	6000
Trichloroethylene	6700
OTHER CHEMICALS	
Bromine (77 F)	6700
Chlorine, dry (77 F)	7000
Chlorofluoro Alkanes (Isotron 13)	6900
Hydrogen Peroxide, 90% (77 F)	5500
Phenol	5700

[a] 5-mil film. Source: Barnhart, et al.

Let's put VAC-ARC® Steels into your critical design picture...

Where design criteria spells out the need for high strength, toughness and ductility at low and elevated temperatures, Vac-Arc Steels will fit the picture.

Vac-Arc Steels are produced by Latrobe's consumable electrode vacuum-melting process—an *experienced* process which results in superior cleanliness, lower gas content, improved ingot structure and outstanding longitudinal and transverse mechanical properties.

Various grades of Vac-Arc steels are regularly produced in a range of sizes and shapes: PANDEX (A-286), INCOLOY 901 and V-57 for high temperature applications; MV-1 (M-50) and REGENT (52100) for critical bearing design; DYNAFLEX (H-11) for jet aircraft, jet and missile components; AGT (9310) for carburized aircraft and other critical gearing.

Send us your design specifications or call your nearest Latrobe representative for experienced *technical* assistance.

Send today for Vac-Arc Steel Catalog showing comparative physical and mechanical properties.

LATROBE STEEL COMPANY

LATROBE, PENNSYLVANIA

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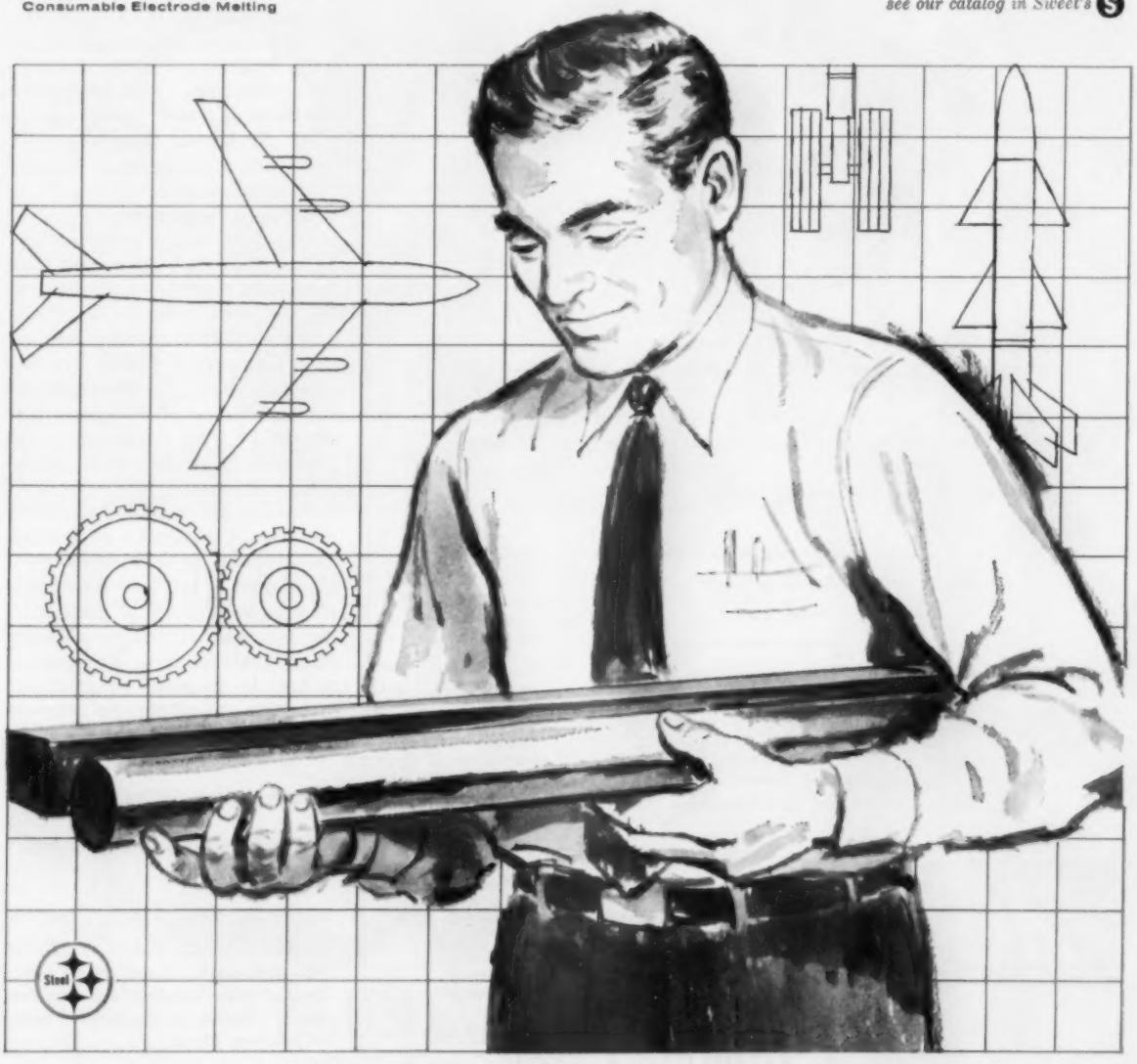
Metalmasters

©Latrobe's Trade Name for Vacuum Consumable Electrode Melting

see our catalog in Sweet's S



For more information, turn to Reader Service card, circle No. 422

•tolerances
•soundness
•intricacy

"Believed Impossible"

WAUKE-SHA CASTINGS

Before now . . . it was thought impossible to cast alloys to dimensional tolerances of ±.005, without expensive machining.

Exclusive Wauke-Sha ceramic molds prevent voids, even with light and heavy adjacent sections, reproduce hairline intricacies without porosity or surface blemish. Only this patented Wauke-Sha process assures:

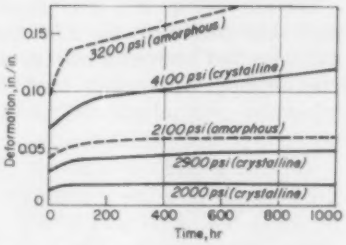
- intricate parts with no costly machining
- hairline reproduction of detail
- no cracking or tearing
- no porosity, internal voids, cracks
- no surface gas holes, blemishes, inclusions

Wauke-Sha castings make possible full design flexibility without limitation on casting size. Every day . . . Wauke-Sha castings are meeting the severe conditions in the nuclear field, where "soundness" is imperative.

Waukesha Foundry Company

WAUKESHA FOUNDRY CO.
Dept. F 18, Waukesha, Wis.
Manufacturers of corrosion-resistant castings, inclusive of non-galling alloys, Stainless Steel, Waukesha Metal, Monel, Pure Nickel, Inconel, Ni-Resist, plus special Nickel-Chromium Alloys for specific applications.

For more information, turn to Reader Service card, circle No. 322



9—*Preliminary tensile creep data on RC 2525 fluorocarbon.*

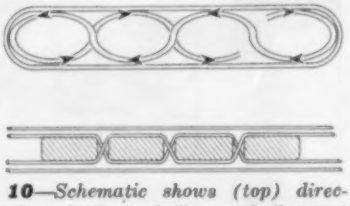
strength or higher was regarded as excellent.

Fig 9 shows preliminary tensile creep data for five stress levels in both crystalline and amorphous specimens. Creep data appear quite similar to those for CFE fluorocarbon materials, i.e., chlorotrifluoroethylene.

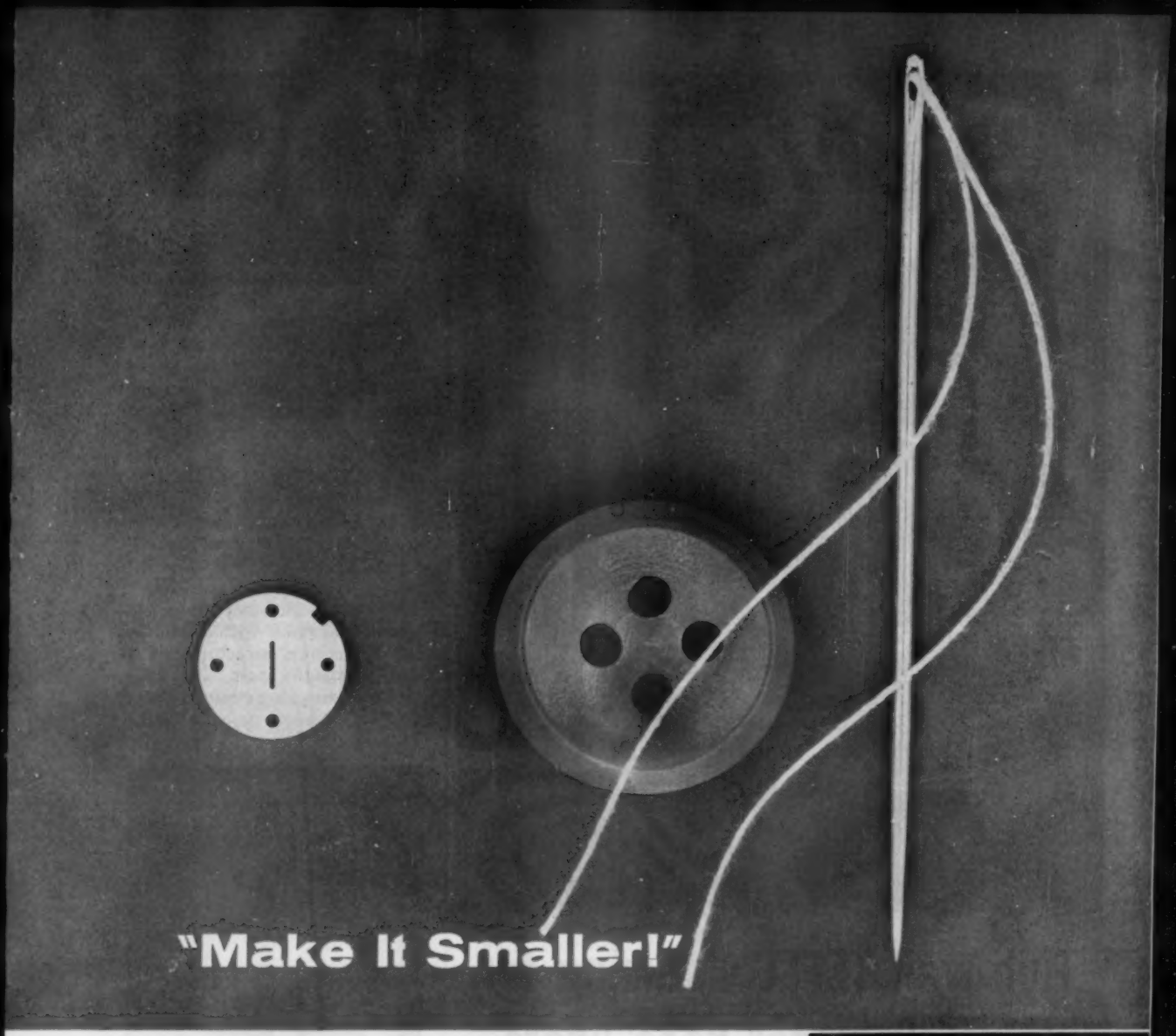
Processing highlights

To engineers and materials specialists the most important new processing techniques reported at the meetings were probably 1) a new method of developing continuous filament-reinforced plastics structures, and 2) a new technique for combining PVC (polyvinyl chloride) with glass-reinforced polyester to produce chemical resistant structures.

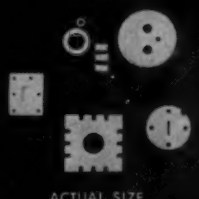
Plastics like bamboo—Studying the fibrous structure of bamboo has resulted in a winding technique used to fabricate continuous filament-reinforced plastics having the basic structural efficiency of natural bamboo. The process makes it possible to construct truss-like members in various basic sections and put them to-



10—*Schematic shows (top) direction of fiber winding and (bottom) use of winding blocks (shaded areas) to position fibers.*



From miniature to sub-miniature to micro, the electronics industry is constantly striving to reduce the size of electronic components. As a result, there is an increasing demand for ceramic in smaller and smaller sizes. Coors is meeting this demand by making small-scale ceramic parts in mass production quantities at precision tolerances. Write for Design Data Sheet 7002, describing Coors manufacturing methods and facilities for small ceramic parts, and latest examples. Or call your nearest Coors Regional Sales Manager: WEST COAST, *William S. Smith, Jr., EM 6-8129, Redwood City, Calif.;* MIDWEST, *John E. Marozeck, FR 2-7100, Chicago, Ill.;* CENTRAL, *Donald Dobbins, GL 4-9638, Canton, Ohio;* EAST COAST, *John J. McManus, MA 7-3996, Manhasset, N. Y.;* NEW ENGLAND, *Warren G. McDonald, FR 4-0663, Schenectady, N. Y.;* SOUTHWEST, *Kenneth R. Lundy, DA 7-5716, Dallas, Texas;* SOUTHWEST, *William H. Ramsey, UN 4-6369, Houston, Texas.*



ACTUAL SIZE

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ALUMINA CERAMICS

Coors Porcelain Company

600 NINTH STREET • GOLDEN, COLORADO

For more information, circle No. 409

Thin-wall TEFLON* tubing for large diameter hose liners

The unique properties of "Teflon" . . . the weight saving of walls as thin as 40 mils . . . the large diameters needed in steam, chemical and food products hose liners. R/M now gives you all these advantages in either TFE or FEP "Teflon" tubing meeting latest FDA requirements.

Diameters to 4 in. available in standard 15′ 6″ lengths . . . etched on OD for bonding. Cover these liners with any material you want—confident that you have used the best liners available for chemical, acid and moisture resistance.

This is the kind of "Teflon" experience for which R/M is known. If you have an application where "Teflon" can do the job better, R/M can help you do it best. Write for complete information on large diameter thin-wall tubing and other R/M "Teflon" products or contact your nearest R/M district office.

*Registered TM for Du Pont fluorocarbon resins

R/M

PLASTIC PRODUCTS DIVISION
RAYBESTOS-MANHATTAN, INC.
Manheim, Pa.

BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2
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SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL

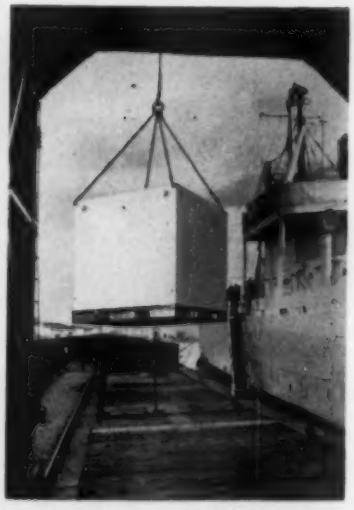
For more information, turn to Reader Service card, circle No. 334

gether in much the same way as parts of an Erector set. The technique was described by C. A. Knoppel of Proman, Inc. (SPE).

The technique is shown schematically in Fig 10. Winding blocks are used to position the continuous glass strands. Tooling can be altered to produce "trusses" of a variety of cross-sectional configurations, including L, T, H, U, X and box frames, and in a variety of curved segments. The trusses are joined by bonding, mechanical fastening, or a combination of the two.

Resulting structures are said to compare favorably with aluminum and magnesium structures on a strength-weight basis.

Glass-polyester laminated to PVC—Find a way to combine the



***Low temperature box** designed for transporting frozen foods, is 8 x 8 x 8 ft, and consists of reinforced plastics molded skins with 5-in. urethane insulation in walls. Molded by Heil Co., the container is designed for transporting foods frozen by Lique Freeze Corp. of America at —320 F liquid nitrogen temperatures. Design permits boxes to be held safely up to four weeks in 90 F surroundings without additional refrigeration. Design, fabrication and testing of the container were described by K. C. Sanders of Heil Co. (SPI)*

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many who may find it useful to review fundamentals from time to time.

Methods of Carburizing Alloy Steels

Carburizing is a means of impregnating the surface of steel with carbon, usually to very limited depths. Its purpose is to provide a hard, wear-resisting "case," or outer shell. Alloy steels, correctly handled, can be case-hardened without sacrificing desirable core properties.

There are three types of carburizing in general use:

Liquid Carburizing—The medium here is a hot-salt bath composed basically of cyanide compounds. The steel is immersed in the bath, the period of immersion depending upon the analysis of the steel and the depth of case desired. Liquid carburizing is a convenient method of producing thin, hard, wear-resisting cases, generally within the depth range of 0.02 to 0.03 in. However, deeper cases may be obtained, the actual depths depending upon economics and end uses.

Gas Carburizing — This method employs a furnace in which a carbonaceous atmosphere is created; i.e., gases that are high in carbon components, or those containing carbon. Steel subjected to gas carburizing can be case-hardened to depths generally ranging from 0.01 to 0.04 in. When quenching takes place immediately after carburizing, distortion can be kept to a minimum.

Pack Carburizing — Where the pack method is used, the parts to be carburized are buried in a container of dry carbonaceous materials. The container is sealed tight to prevent the infiltration of air, placed in a furnace and kept there for eight hours or more, the actual time depending upon the depth of case desired. Pack carburizing is particularly suitable where a deep case is essential (0.06 in. and over), although medium cases in the 0.04-to-0.06-in. range are possible.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

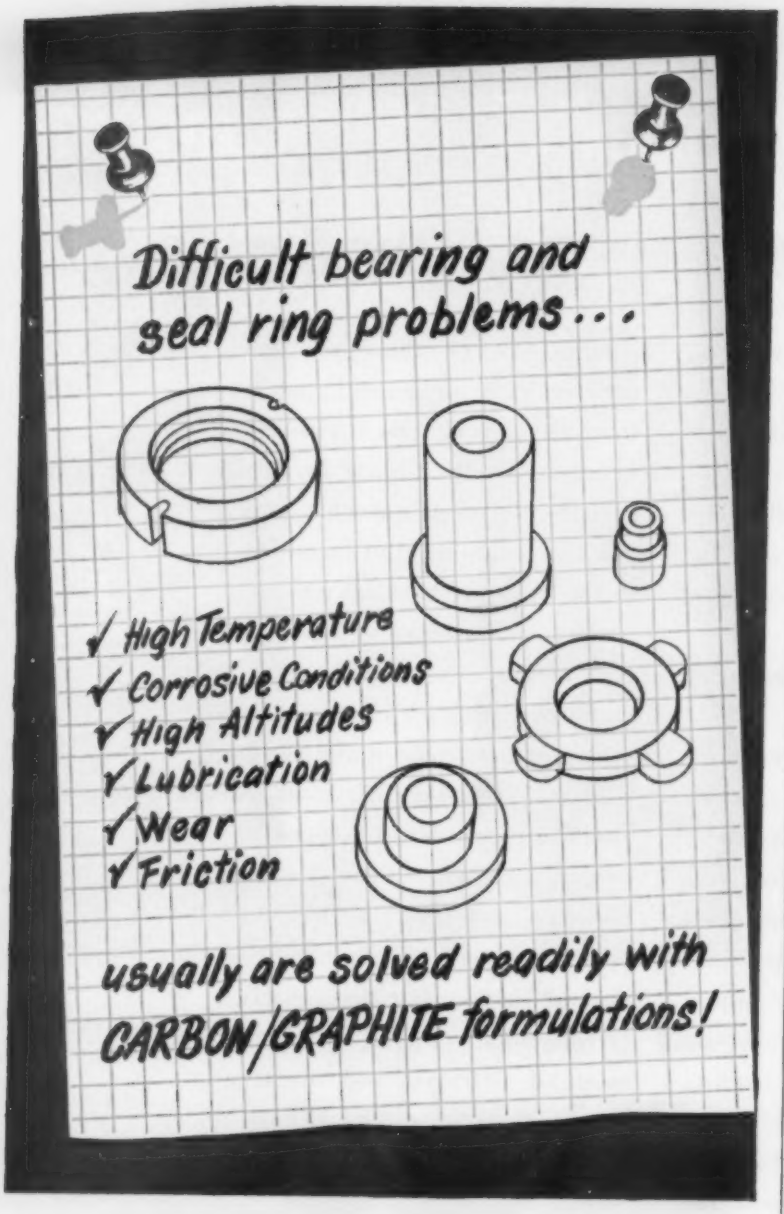
Steel for Strength ... Economy ... Versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 367



Many standard grades . . . countless specials . . . with physicals to match your performance requirements exactly. Outline your application for a prompt recommendation. STACKPOLE CARBON Co., St. Marys, Pa.

STACKPOLE

ROCKET NOZZLES • PUMP VANES • TURBINE RINGS • GRAPHITE CHEMICAL ANODES • VOLTAGE REGULATOR DISCS • BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT • WELDING & BRAZING TIPS • ELECTRICAL CONTACTS • CERAMIC MAGNETS • FERROMAGNETIC CORES • FIXED & VARIABLE COMPOSITION RESISTORS . . . and many other carbon, graphite and electronic products.

For more information, turn to Reader Service card, circle No. 328

toughness and chemical resistance of PVC (polyvinyl chloride) with the structural strength and heat resistance of glass-reinforced polyester resins, and you should have an excellent material for chemical resistant structures. Development of just such a technique, making use of a newly developed polyester resin which adheres to specially prepared PVC, was described by G. Ader of Artrite Resins, Ltd. (SPI).

The new polyester, developed by Artrite, can be applied to the PVC by wet lay-up or spray techniques. Present evaluations indicate that a number of types of PVC can be used. Rigid PVC appears to provide the best results, though a small amount of plasticizer content can probably be tolerated.

The PVC surface to which the polyester is to be applied must be thoroughly and evenly roughened, by either hand sanding with a

Where to Get More Information

More details on these developments can be obtained from either the authors or the societies.

The meetings were:

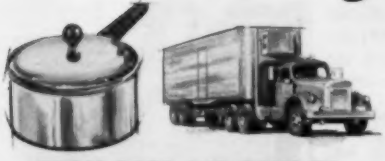
▸ 17th Annual Technical Conference, Society of Plastics Engineers, Inc., Jan '61, Washington, D. C. Reprint books are available ($7.50 to members; $12.50 to nonmembers) from the society: 65 Prospect Ave., Stamford, Conn.

▸ 16th Technical and Management Conference, Reinforced Plastics Div., Society of the Plastics Industry, Inc., Feb '61, Chicago. Reprint books are available ($10) from the society: 250 Park Ave., New York 17.

The meeting at which each paper was presented is indicated in parenthesis in the text, i.e., (SPE) or (SPI).

THIS MAGIC METAL IS ALUMINUM COMBINED WITH STAINLESS STEEL
The unretouched photograph below shows a specimen of Fairmont Stainless Steel Clad Aluminum almost three times actual size. Note the fine bond line of this homogeneous metal—aluminum inseparably bonded to stainless steel.

Now Fairmont creativity combines the advantages of two great metals



FROM POTS AND PANS TO REFRIGERATED TRUCK BODIES

Cooking utensils which combine the excellent heat transfer properties of aluminum with the resistance to food acids of stainless steel. Or refrigerated transport which meets stainless regulations and also makes use of aluminum's light weight for bigger payloads. Or what have you? Fairmont Stainless Clad Aluminum will revolutionize a complete field of metal fabrication. Get in on the ground floor with Fairmont!

THEY SAID IT WASN'T PRACTICAL. But an intensive research program has been concluded, and Fairmont's new Stainless Clad Aluminum is now being rolled on a production basis, via patented methods providing a perfect molecular bond.

By successfully combining the ductility, light weight and high conductivity of aluminum with the strength, corrosion resistance and lustrous beauty of the stainless steel, Fairmont has opened doors wide to a thousand and one product improvements leading to more sales and new products by fabricators of all kinds.

Initially, Fairmont Stainless Clad Aluminum is being produced in flat sheet and flat circles or blanks. Other sheet forms will be made available in the not too distant future. For fabricators who know it pays to plan ahead, NOW is the time to call in a Fairmont representative for detailed facts, figures, application ideas.

FAIRMONT ALUMINUM COMPANY

SUBSIDIARY OF **CERRO CORPORATION**

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FAIRMONT • WEST VIRGINIA

FAIRMONT 3010 • CABLE ADDRESS: FARMON

For more information, turn to Reader Service card, circle No. 411

Two cost-cutting advantages in modern Hackney Air Receivers

✓ **Seven standard capacities**—Costs come down when you specify Hackney air receivers. In the Hackney line, you can choose standard capacities that will best suit many of your needs from stock.

Modern Hackney air receivers depart from conventional design to give you stronger, lighter construction. Made with two smooth seamless shells, cold drawn to exact diameters and uniform wall thicknesses, they meet the demands of all pressure vessel codes. *One* circumferential weld minimizes seam area of the tank.

✓ **Supplied to your schedule**—Hackney 2-piece air receivers can be supplied in *quantities* on a schedule geared to *your* assembly operations. Openings, fittings, legs and saddles for compressor and motor can be located per your specifications. And should you need special capacities or construction features, our experience as well as our complete facilities can point the way to more economical production costs.

Capacities: *Standard* horizontal—30, 60, 80 and 120 gallons. *Standard* vertical—30, 60 and 80 gallons.

For complete specifications and details, send for our new air receiver bulletin, No. AR-1.

Pressed Steel Tank Company

Manufacturer of Hackney Products Since 1902

1442 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

Hackney

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 399

fine abrasive, or sand blasting with a fine grit. The surface must then be thoroughly cleaned. Polyester should be applied immediately following cleaning. The PVC can be formed to the final shape either before or after the surface-roughening operation.

Tests on lap joint bonds between the new polyester and vinyl have all resulted in failure in one material or the other—not in the joint between them.

Contoured Parts Made of Woodchip Material

Molded contoured parts made of a new woodchip material called Delwood are said to offer cost and weight saving advantages when used in place of contoured solid wood parts. The woodchip material consists of wood chips, chopped fiberglass and polyester resin.

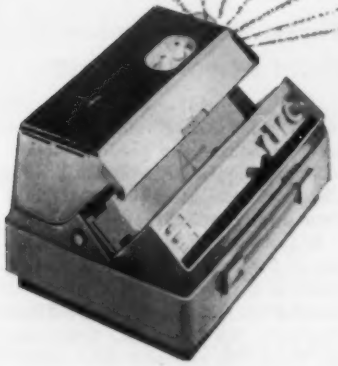
The parts are currently in pilot plant production at Gisholt Machine Co., 1245 E. Washington Ave., Madison 10, Wis.

The producer says the molded parts have better moisture resistance than solid wood parts. Fracture strength is about the same as that of hard maple. The molded wood-

***Wood chips** are mixed with controlled amounts of chopped fiberglass and polyester resin.*

CYCLE TIME CUT 40%

(actual size)
This turbin-type blower rotor is one of 34 parts made of Spencer Nylon used in the new, fully-automatic Anscomatic projector.



. . . WITH SPENCER NYLON

Solving tough injection molding problems is a challenge welcomed by Spencer Nylon. Advanced Spencer Nylon resins speed up production of even the most complex moldings. Here is an example . . .

The molder of the intricate 56-blade Anscomatic turbine fan shown above was able to reduce cycle time 40% by switching to Spencer Nylon 401-A. Altogether, 34 critical parts in this precision Anscomatic projector are made of Spencer Nylon. As a result, it costs less, weighs less, wears less and makes less noise.

The advantages of Spencer Nylon are many. Compared with other nylons, Spencer Nylon resins flow more freely to permit faster cycles and greater versatility of mold design. Because Spencer Nylon contains far less water, expensive drying time is unnecessary.

It will cost you nothing to discover the advantages of Spencer Nylon for yourself. Just contact us at the address below:

SPENCER®

SPENCER NYLON

SPENCER CHEMICAL COMPANY

Dwight Building . . . Kansas City 5, Missouri

For more information, turn to Reader Service card, circle No. 438

For safe stripping of aluminum

ask Oakite

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Strip anything from aluminum even epoxies . . . with complete safety

Salvage expensive aluminum parts *safely* in a tank of Oakite Stripper S-A. It strips the toughest finishes in minutes, with no danger of etching the aluminum beneath. Saves the part . . . saves *you* costs.

Stripper S-A works faster than almost anything else you can try on paints, lacquers, coatings and adhesives, including the new epoxy, acrylic, vinyl and polyester types . . . yet, it's completely safe for such metals as steel, stainless steel, copper and brass as well as aluminum. Has no flash point, works without heat.

And Stripper S-A is only one of a long line of Oakite stripping compounds for safe reclamation of rejects. There are strippers for maximum economy . . . for maximum speed . . . for *any* method of application. ASK THE OAKITE MAN. Or write for Bulletin F-7893, Oakite Products, Inc., 25A Rector Street, New York 6, N. Y.

it PAYS to ask Oakite

OAKITE

over 50 Est. 1909 SCIENCE

years' leadership in industrial cleaning

For more information, turn to Reader Service card, circle No. 380

What's new IN MATERIALS

chip parts are said to hold nails, tacks, staples and screws better than solid wood.

Typical parts that can be made of the new woodchip material include display letters for outdoor signs, shoe lasts, picture frames, reinforcing structures for fiberglass desk tops, and frames for upholstered furniture. KEY NO. 610

***Woodchip material** is molded at pressures between 300 and 500 psi into contoured parts such as the one shown here.*

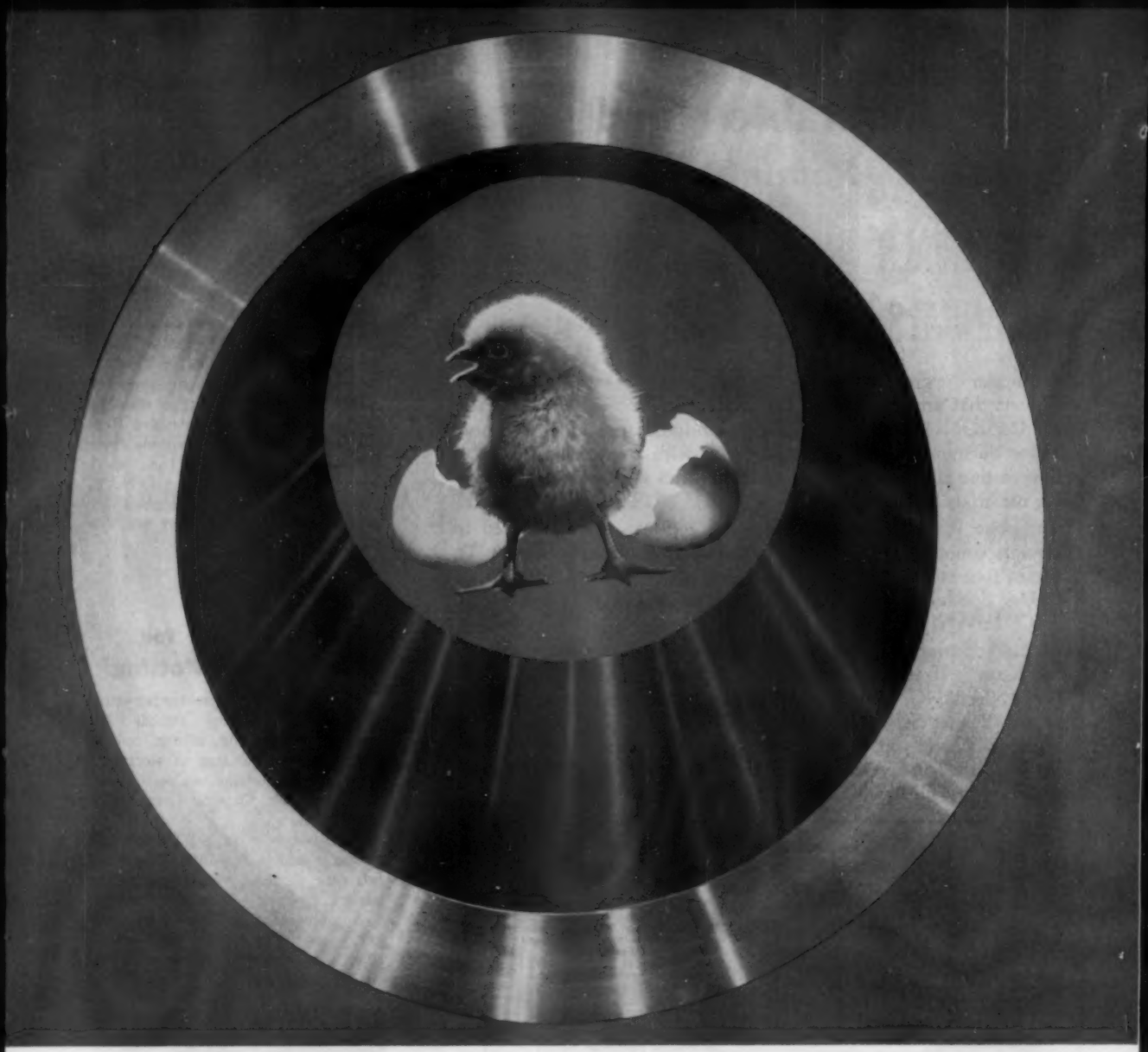
Three New Adhesives Bond Plastics, Metals

Two epoxy adhesives and a synthetic rubber-base adhesive have been introduced for bonding metals, plastics and other nonmetallics to themselves and to other materials.

Two epoxy adhesives

A fast curing, two-part epoxy adhesive for bonding metals to metals, plastics to metals and plastics to plastics is available from Allaco Products, 238 Main St., Cambridge 42, Mass. The adhesive cures after 1 min at room temperature and after 45 sec under infrared lamps. KEY NO. 611

A clear, two-part epoxy adhesive for bonding glass to glass and metals to glass is made by Hysol Corp., 322 Houghton Ave., Olean, N. Y. The adhesive can be used over the temperature range —50 to 150 F. It has a shear strength of 2400 psi. The new adhesive is called Epoxi-Patch No. 0151. Resin and hardener are



WHAT'S NEW IN TUBING?

Here's another ACIPCO "first"... ACIPCO CERAM-SPUN®, the ceramic mold process* that offers greater versatility in design, new concepts in economy.

WHAT THESE ADVANTAGES MEAN TO YOU! ACIPCO is not limited by equipment sizes. Now, for the first time, you can order the exact tube O.D. you need... from 2.25" to 50". As-cast lengths can vary from 4 feet to 20 feet, longer lengths are made by welding; and wall thicknesses range from .25" to 8". Furthermore, these tubes can be furnished with the exact combination of physical, chemical, and metallurgical properties required by your specifications.

THE RESULT: YOU SAVE MORE! No more unnecessary metal waste or excessive machine charges.

Too, ACIPCO's complete "under one roof" operations — including heat treating, machining and welding — eliminate the delays and additional high costs often involved in buying from multiple sources. Before you order another steel tube . . . first investigate the many advantages ACIPCO offers. Contact ACIPCO STEEL PRODUCTS, Division of American Cast Iron Pipe Company, Birmingham 2, Alabama.

*Patent applied for

ACIPCO CERAM-SPUN®
STEEL TUBING

For more information, circle No. 410

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packaged in flexible tubes for easy mixing. KEY NO. 612

Synthetic rubber adhesive

The synthetic rubber-base adhesive has been designed for bonding paper and paper-backed labels to polyethylene squeeze bottles, closures and cable sheaths. It is called Rez-N-Glue No. 298 and is available from Schwartz Chemical Co., Inc., 50-01 2nd St., Long Island City 1, N. Y. The adhesive can be applied by spraying or brushing. KEY NO. 613

Silicone Rubber for Thick-Section Potting

A new RTV (room temperature vulcanizing) silicone rubber for thick-section potting, filling, embedding and encapsulating of electronic parts and assemblies has been introduced by Dow Corning Corp., Midland, Mich.

Identified as Silastic RTV 601, the rubber is said to flow into and around intricate designs, completely filling narrow cavities and hairline cracks.

An important feature of the rubber is excellent control over set-up time. Under normal conditions Silastic RTV 601 sets up to a tack-free

***Cured silicone rubber** can be cut away to permit repair of defective parts. When fresh rubber is poured into the cut-out section, it bonds to the original rubber and completely reseals the repaired assembly.*

For high strength without excessive weight, the designer of this heavy truck chose Tenzaloy for the front engine supporting frame.

TENZALOY

Why TENZALOY is the most widely used high-strength aluminum casting alloy

Among high-strength, self-aging aluminum casting alloys, Tenzaloy has won greatest acceptance and widest use by designers because of its unique all-round combination of properties. Outstanding among these special qualities are:

- High yield and tensile strength, combined with adequate ductility
- Exceptional machinability
- Remarkable dimensional stability
- High impact, shock resistance

When Tenzaloy is specified, one big problem is eliminated: heat treatment. Without any artificial thermal treatment, Tenzaloy castings will precipitation-harden at room temperature to give properties normally obtainable only by the expensive solution treating, quenching, and artificial aging of the heat-treatable alloys.

Here are typical properties for Federated Tenzaloy:

Tensile strength	35,000 psi
Yield strength	25,000 psi
Elongation (in 2 in.)	4-5%
Brinell hardness No.	74
Impact strength (Charpy in ft.-lbs.):	
Notched	3
Un-notched	14
Electrical conductivity	35%

Tenzaloy also is corrosion resistant, has superior ductility, and is easily anodized, dyed and polished to brilliant decorative finishes. Castability is excellent in green sand, plaster, investment, shell, oil-bonded sand and precision molds of all kinds. No special techniques are required for handling Tenzaloy in the foundry. Since Tenzaloy has mechanical properties equivalent to such common heat-treated alloys as 195T6, 355T6, 356T6 and 319T6, it can be substituted in applications where any of these heat-treated alloys are presently used.

It is particularly suited to high-strength designs where load carrying capacity and impact strength are essential. For example: frames, brackets, levers, bases, housings, missile ground handling equipment, jet aircraft turntables, explosion-proof enclosures, heavy-duty wheel hubs and cable drums, to name a representative few.

Tenzaloy can widen your design possibilities, increase production efficiency, improve your products, reduce costs. Get complete facts on its physical and mechanical properties by writing for Bulletin No. 103 R5 to: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

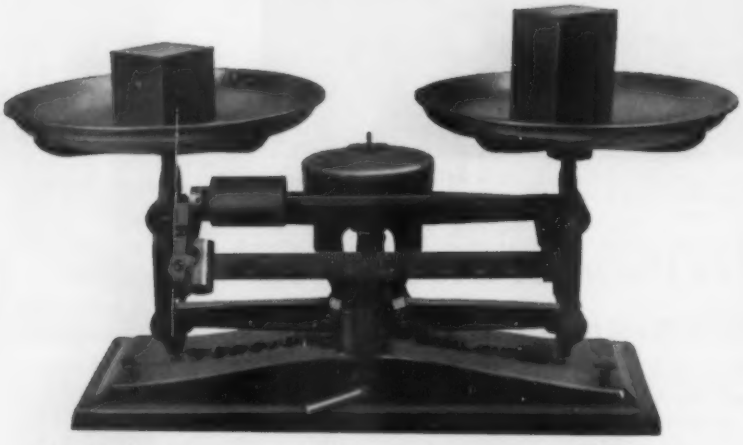
FEDERATED METALS DIVISION **ASARCO**

American Smelting and Refining Company
120 Broadway, New York 5, N. Y.

For more information, turn to Reader Service card, circle No. 432

KENNERTIUM*

. . . a new alloy 50% heavier than lead



Both blocks on the scales weigh the same. However, the lead block on the right occupies 50% more space than the cube of Kennertium at the left.

Usually, when high density or concentrated mass is desirable . . . small volume is, too. Ballasts and counterweights for missiles and jet aircraft, for example, must often fit very small areas. For these and many similar applications, Kennertium—a special blending of tungsten and other elements—is now being used.

In the above photograph, the block on the left is Kennertium . . . the one on the right is lead. For equal *volume*, Kennertium provides 50% more weight than lead. The high specific gravity of the material makes it particularly suitable for counterweights on the wings and empennage of aircraft (inset at right).

Used as a radiation shielding material, Kennertium (containing over 90% tungsten) is more effective than other materials.

Still another use is for high rotational inertia . . . such applications as gyroscopic rotors and torsional vibration dampeners.

The piece shown in the lower inset indicates the excellent machinability of Kennertium. It also has high malleability (10% elongation) at high tensile strength (115,000 psi). For more information, send for Kennertium Properties Booklet. KENNAMETAL INC., Department MDE, Latrobe, Pennsylvania. 34226

*Trademark

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KENNAMETAL
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For more information, turn to Reader Service card, circle No. 383

What's new IN MATERIALS

solid within 12 hr after catalyzation. By adjusting catalyst concentration or cure temperature, set-up time can be lengthened or shortened as desired without affecting the properties of cured parts.

Dow says parts or sections made from the new rubber can be put into service immediately after they have been cured 24 hr at room temperature. Physical and electrical properties are uniform throughout the cured material. The cured rubber is useful over the temperature range —100 to 500 F.

The silicone rubber is supplied as a low viscosity fluid and is marketed in 1, 10, 50 and 75-lb containers. It has a shelf life of at least four months when stored at temperatures below 70 F. KEY NO. 614

PROPERTIES OF SILASTIC RTV 601 RUBBER

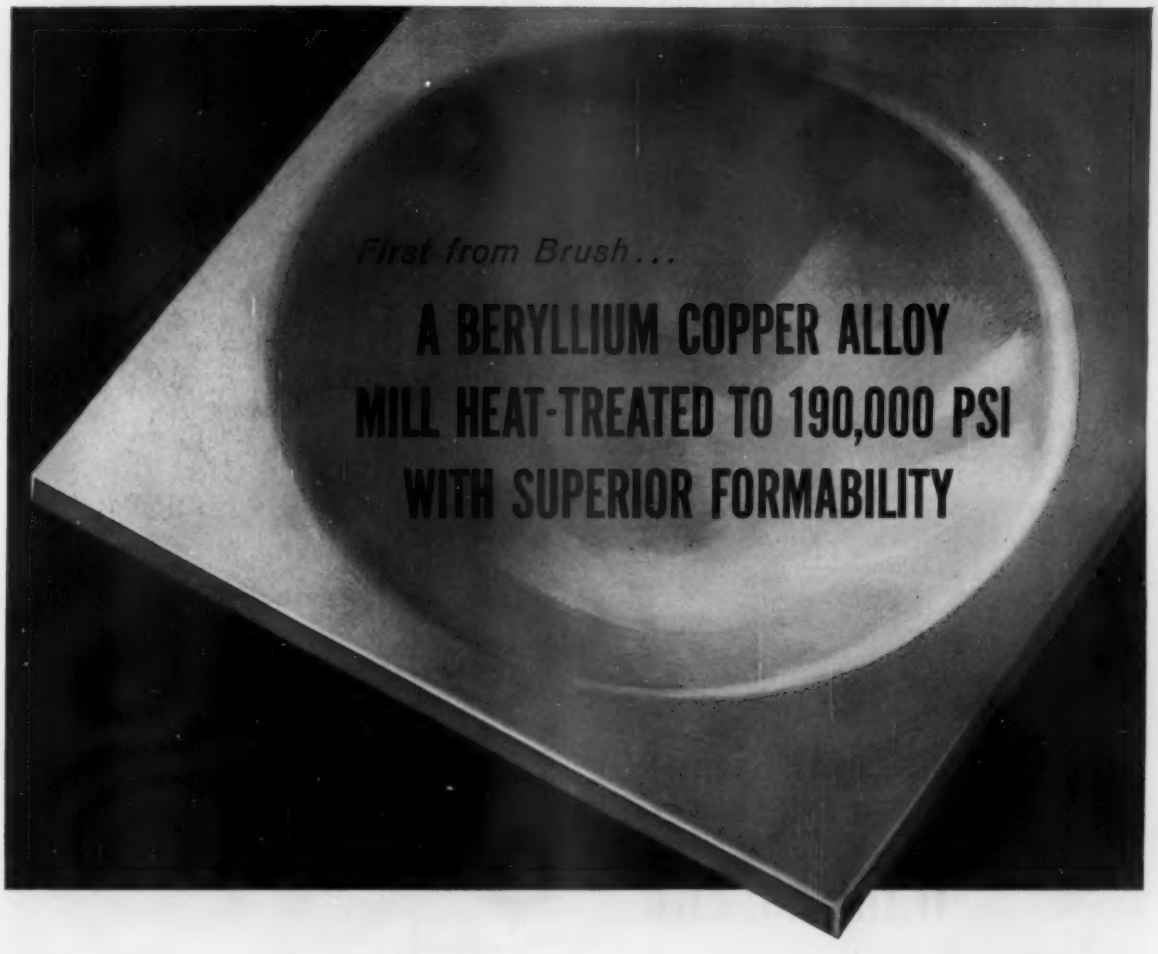
PHYSICAL PROPERTIES	
Specific Gravity	1.29
Water Absorption (7 days), %	0.3
Coef of Ther Exp, 10^{-4} per °F	4.5
MECHANICAL PROPERTIES	
Tensile Strength, psi	300
Elongation, %	150
Brittle Point, F	−100
Durometer Hardness (Shore)	A40
ELECTRICAL PROPERTIES*	
Dielectric Strength, v/mil	550
Dielectric Constant	
60 Cps	3.50
10^3 Cps	3.44
10^5 Cps	3.37
Dissipation Factor	
60 Cps	0.020
10^3 Cps	0.011
10^5 Cps	0.004
Volume Resistivity, ohm-cm	3.0×10^{13}

*Tests conducted on specimens aged 24 hr at 50% RH.

Manganese Bronze for Screw Machine Work

A new leaded manganese bronze for high quality screw machine work has been introduced by Ampco Metal, Inc., Box 2004, 1745 S. 38th St., Milwaukee 1, Wis.

The alloy, called Ampcoloy 668, is described as a high strength, free-machining material that has good hot working characteristics. The material is expected to find use in

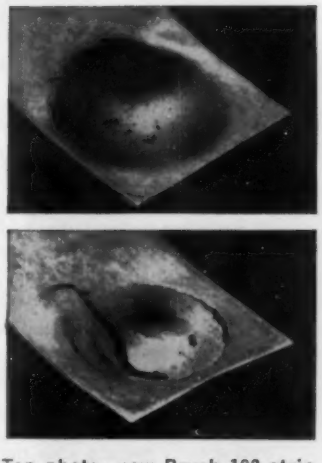


New Brush 190 eliminates need for customer heat-treating

Formable to a greater degree than ever before possible with a high strength mill heat-treated beryllium copper strip, Brush 190 Alloy marks a significant technological advance.

With a tensile strength of 190,000 psi, it eliminates the need for customer heat-treating. And, as with all beryllium copper alloys, it has good electrical and thermal conductivity.

Brush 190 Alloy meets both ASTM Specification B 194 and Federal Specification QQ-C-533. Write today for technical data sheet. For additional information, call your local Brush representative or contact The Brush Beryllium Company, 5209 Euclid Avenue, Cleveland 3, Ohio, Phone ENdicott 1-5400, TWX CV 506.



Top photo: new Brush 190 strip successfully formed in the mill heat-treated condition.

Lower photo: Although mill heat-treated and having a lower tensile strength of 160,000 psi, 165 Alloy—recommended for parts where added strength and formability of Brush 190 is not required—could not take the identical forming operation.

THE BRUSH BERYLLIUM COMPANY

For more information, turn to Reader Service card, circle No. 405

in BRIGHT ANNEALED STAINLESS STEEL STRIP . . .

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. . . when beauty must be bright and durable, many products are made as they should be with

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FIRST to guarantee—unconditionally—that its product would successfully survive the Automotive Industry's severe tests for brightness and corrosion-resistance . . . tests the product did pass, a performance that has caused thirteen competitors to try to copy Wallingford's unique method, a method that remains unmatched; and a performance that convinced one major automotive company to specify Wallingford Type 201 Bright Annealed exclusively!

FOREMOST in total Bright Annealed tonnage produced, in installed capacity for producing it, and in years of research, development, and application experience . . . eleven of them rewardingly spent in the refinement of this super functional and decorative material.

FINEST . . . our claim that Wallingford Bright Annealed is the finest is repeatedly reinforced by our customers' outspoken praise of it. Ask them. References willingly supplied on request.

And ask us how Wallingford Bright Annealed can enhance the beauty of your product, endow it with high corrosion resistance, and greatly reduce your finishing costs. Describe your application and we'll provide specific recommendations.

Progress in Metals Since 1922

THE WALLINGFORD STEEL CO.

TONNAGE *on a Laboratory Basis*

WALLINGFORD, CONNECTICUT, U.S.A.

For more information, turn to Reader Service card, circle No. 408

What's new IN MATERIALS

bushings, bearings, gears, cams, connecting rods and valve stems. It is supplied in extruded solid and hollow bar forms.

The producer says that Ampcoloy 668 has better corrosion resistance, higher tensile strength and less weight than conventional cast bearing bronzes. Uniform composition, temper and lead dispersion in the alloy are said to prevent excessive tool wear and breakage.

KEY NO. 615

Synthetic Felts Are Strong, Heat Resistant

A new series of felts called Fiberloc has been introduced by Felters Co., 1803 Empire State Bldg., New York City. Made of Orlon, nylon, Dacron, Arnel, viscose, acetate, polypropylene and other synthetic fibers, the felts have tensile strengths up to 1500 psi. They also have good resistance to acids, alkalis and mildew, and withstand temperatures up to 350 F.

Recommended uses include gaskets, seals, insulation, reinforcement, padding and wicks.

The felts are supplied in rolls and sheets, and as precision cut parts and shapes. They are made by a new mechanical bonding process, details of which have not been revealed.

KEY NO. 616

Dry Film Lubricants Are Noncorrosive

Specially treated molybdenum disulfide powders with a pH of 7.0 are said to be noncorrosive under conditions of moisture and high heat. Conventional molybdenum disulfide powders have a pH on the acid side (3.4 to 4.9) and are likely to promote corrosion in the presence of moisture.

The treated powders are formulated into a variety of lubricants by McGee Chemical Co., Inc., 8000 West Chester Pike, Upper Darby, Pa. They are sold under the tradename McLube.

No. 830 is a silicone-alkyd oven drying coating that is said to have

*Johnson reel (Denison-Johnson Corp.); Imperial 8 radio (Admiral Corp.); Aqua Hone sharpener (Sun Enterprises, Inc.)

IMPLEX in a man's world

IMPLEX, the high impact acrylic, goes where the tough jobs are . . . where great strength and rigidity, plus resistance to staining, are important selling points for a product. The fishing reel cover, transistor radio case and water-powered knife sharpener housing shown above* have rugged durability because they are molded of IMPLEX. This Rohm & Haas molding material also provides an attractive appearance by imparting high surface gloss and rich colors. Our design staff and technical representatives will be pleased to help you use IMPLEX for your present and prospective products—to your advantage. Just write and tell us about a specific project.

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IMPLEX

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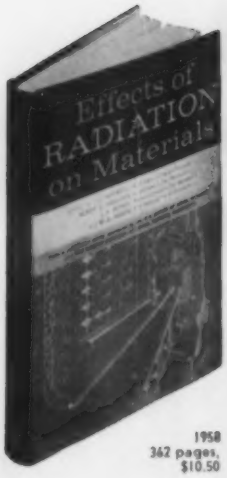

1958
342 pages,
$10.50

Effects of RADIATION on Materials

Edited by **J. J. HARWOOD,** U. S. Office of Naval Research; **HENRY H. HAUSNER,** Consultant to The Martin Co.; **J. G. MORSE,** Nuclear Div., The Martin Co.; and **W. G. RAUCH,** U.S. Office of Naval Research

The changes that radiation produces in metals, ceramics, plastics and a wide variety of other materials are thoroughly covered in this momentous new book. It contains the papers delivered at the radiation effects colloquium jointly sponsored by the Office of Naval Research and The Martin Company at Johns Hopkins University in March 1957.

Twelve leading authorities analyze the results of their own actual experiments with various materials. Solid state physicists classify fundamental and qualitative effects according to type. Metallurgists and chemical engineers make a quantitative evaluation of radiation effects on physical properties. The book also includes current concepts of radiation effects and discusses experimental approaches to radiation studies.

The outstanding authorship, and the subject's timeliness and importance establish this book as a milestone in technical literature. An extensive bibliography brings together the enormous amount of literature on the subject from every part of the world.

CONTENTS AND CONTRIBUTORS:

Defects in Solids and Current Concepts of Radiation Effects—G. J. DIENES, Brookhaven National Laboratory.
Experimental Approaches to Radiation Studies—Radiation Sources and Desimetry—J. C. WILSON, Oak Ridge National Laboratory.
Radiation Effects on Physical and Metallurgical Properties of Metals and Alloys—E. S. BILLINGTON, Oak Ridge National Laboratory.
Influence of Radiation Upon Corrosion Behavior and Surface Properties of Metals and Alloys—M. SIMNAD, General Atomics.
Effects of Radiation on Electronic and Optical Properties of Inorganic Dielectric Materials—R. SMOLOCHOWSKI, Carnegie Institute of Technology.
Effects of Radiation on Semiconductors—H. Y. FAN and K. LARK-HOROVITZ, Purdue University.
Cores, Liquid Coolants and Control Rods—C. E. WEBER, General Electric Co. (Knolls Atomic Power Laboratory).
Moderators, Shielding and Auxiliary Equipment—G. R. HENNIG, Argonne National Laboratory.
Experimental Techniques and Current Concepts—Organic Substance—M. BURTON, University of Notre Dame.
Effects of Radiation on Behavior and Properties of Polymers—A. CHARLESBY, Tube Investments Ltd., Cambridge, England.
Kinetics of the Gamma-Induced Graft Copolymerization of Vinyl Acetate to Teflon—A. J. RESTAINO, Nuclear Div., The Martin Co.
Bibliography—H. FRIEDEMANN.

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excellent resistance to moisture and weather. It withstands temperatures up to 750 F.

No. 835 is a silicone-phenolic oven drying coating that produces a hard surface with high film strength. It has excellent resistance to moisture, weather, chemicals and heat.

No. 500 is a noncarbonizing, water insoluble, nongumming oil dispersion containing large amounts of treated molybdenum disulfide powders. It can be used over the temperature range —45 to 480 F.

No. 601 is a dispersion of treated molybdenum disulfide powders in an emulsion of oil and soft water. The oil is noncarbonizing and has a flash point of 490 F. The emulsion contains rust and oxidation inhibitors.

No. 1104 is a chemically gelled grease containing small amounts of treated molybdenum disulfide powders. The grease is said to be superior to conventional soap-gelled greases in heat stability, water resistance and bearing performance. It can be used over the temperature range 10 to 550 F. **KEY NO. 617**

Epoxy-Glass Insulation Good for Class F Use

A new epoxy-glass electrical insulating material is said to retain high dielectric strength and good flexibility under continuous Class F (310 F) temperatures. The insulation, designated No. 2525, is available from Irvington Div., Minnesota

***Electrical insulation** developed by 3M's Irvington Div. is available as slit tapes and sheets in thicknesses from 0.003 to 0.010 in.*

NEW FROM DU PONT...
a thermoplastic "Teflon" film that's easy to fabricate

TEFLON® FEP FILM

New "TEFLON"* FEP-fluorocarbon film has nearly *all* the unique advantages of "TEFLON" TFE with one big plus. It's a true thermoplastic that can be easily formed and sealed. One type of this new film can be applied *with* adhesives, another can be laminated and heat-bonded *without* them.

Here are just some of the advantages of "TEFLON" you get in this new film • Unique antistick and low-friction properties • Chemically inert to practically all known chemicals • Electricals are high (up to 4,000 volts/mil dielectric strength) and *stay* high • Performance stays virtually constant from -250°C. to over 200°C.

"TEFLON" FEP film opens the door to whole new areas of design and product improvement. Mail coupon and start investigating "TEFLON" FEP film for yourself. (Briefly describe the end use you have in mind.)

*Du Pont trademark

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...THROUGH CHEMISTRY

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Film Department 9531-N (T)
Wilmington 98, Delaware

Name_____

Company Name_____

Address_____

_____

Job Function_____

Proposed End Use_____

For more information, turn to Reader Service card, circle No. 388

For more information, turn to Reader Service card, circle No. 401

What's new IN MATERIALS

Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

Some advantages claimed for the material are: 1) it does not discolor after heat aging; 2) it does not contaminate or degrade transformer oils; and 3) it is compatible with all Class F magnet wires.

The producer says the material should find use as an insulation in encapsulated transformers, Class F motors, and oil-immersed distribution transformers. The material is also expected to be used as a slot, phase, coil and interlayer insulation in military units designed for short-term operation at Class H (360 F) temperatures. KEY NO. 618

Vinyl Coating Protects with Single Layer

A new high-solids vinyl coating is said to overcome the application disadvantages of most vinyl coatings which usually require multiple coats to achieve a minimum protective thickness to 5 mils. One coat of the new high-solids vinyl produces a dry film thickness of more than 5 mils when airless spray equipment is used. The same thickness can be achieved in two coats when conventional spray equipment is used.

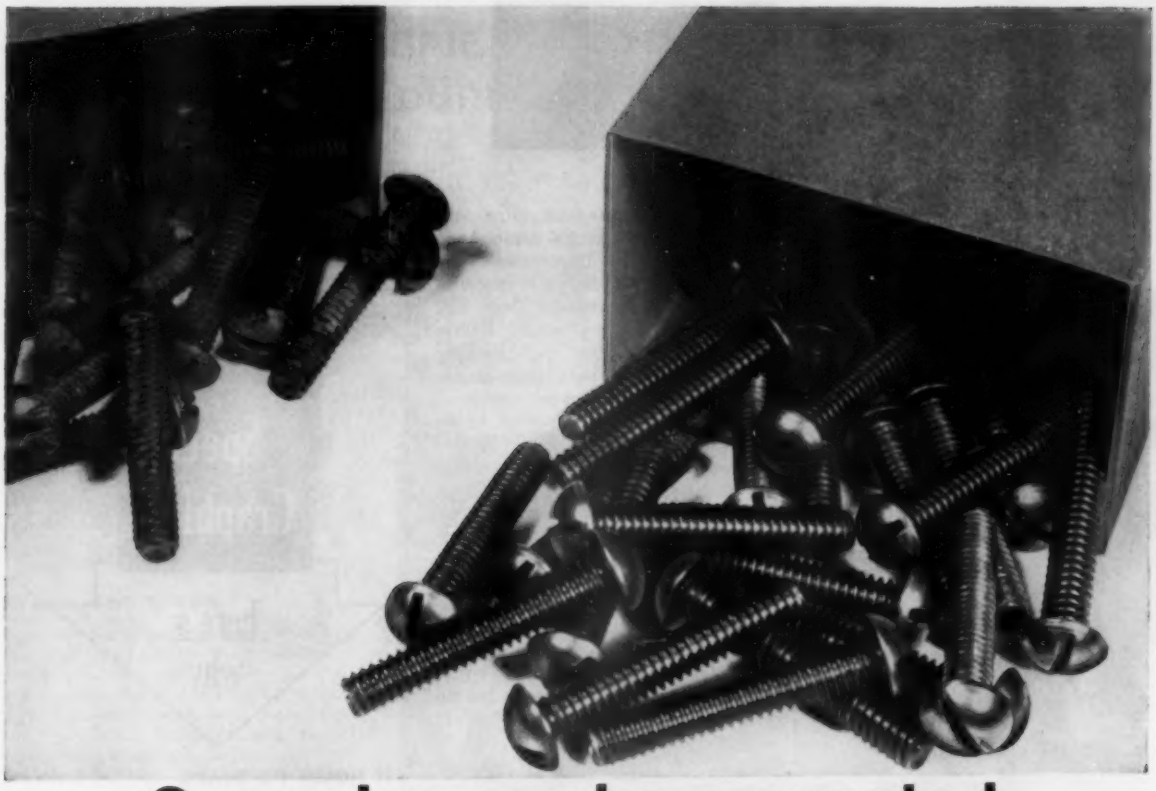
Called No. 99, the coating is now commercially available from Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif. The producer says the coating is designed for use on tank exteriors, ship hulls and other types of structural steel products.

The coating dries to a hard and tough matte finish. The dry coating is said to be abrasion resistant, noninflammable, odorless and nontoxic. KEY NO. 619

Polyurethane Tape Dampens Vibration

A new vibration damping tape is designed for easy application on thin sheet metal. A single layer of the tape is said to provide excellent damping on 0.060-in. thick steel and aluminum sheets.

The tape, called Scotchfoam No.



Corrosion can be prevented with SOLVAY SODIUM NITRITE

Even the finely machined, threaded surfaces of tiny screws can be kept free of rust by treating them with SOLVAY® Sodium Nitrite!

These screws are identical with one important *exception*. The contents of the right-hand box were dipped in a low cost .1% concentration of SOLVAY Sodium Nitrite to form an invisible gamma oxide protective film that guards metal surfaces against corrosion. This easy treatment works equally well on big metal parts—iron or steel sheets, tubes, bars or semi-finished parts during storage or between processing steps. Spray or dip it on, in solution—add it to circulating water systems—combine it with phosphates for greater moisture resistance. In addition, it is reported to suppress degradation in aluminum, tin, monel, copper and brass.

Get the details about the many anti-corrosion uses of SOLVAY Sodium Nitrite and a test sample...

Sodium Nitrite • Calcium Chloride • Chlorine • Caustic Soda • Caustic Potash
Chloroform • Potassium Carbonate • Sodium Bicarbonate • Methyl Chloride
Soda Ash • Ammonium Chloride • Methylene Chloride • Monochlorobenzene
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ALLIED CHEMICAL CORPORATION 42-41
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- ☐ Booklet—"Sodium Nitrite for Rust and Corrosion Prevention"

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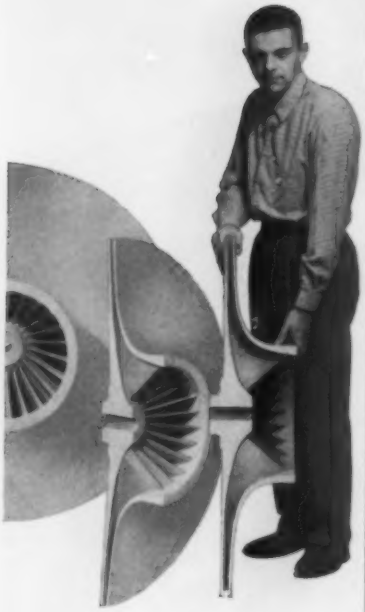

Large aluminum impellers cast smooth and accurate with metallurgical quality for high speed applications are among the specialties of Morris Bean and Company, Yellow Springs 10, Ohio.

BEAN

aluminum
ductile iron
foundries

For more information, circle No. 420

What's new IN MATERIALS

Y-9052, is available from Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn. It consists of an embossed vinyl backing, a specially compounded polyurethane foam and a pressure-sensitive adhesive. Damping occurs when the vinyl backing forces the polyurethane foam to absorb vibrational energy.

The new tape is expected to be used for damping vibration in aircraft, metal cabinets, doors, desks, automobiles, washers, dryers, freezers, typewriters and television sets.

According to 3M, the tape is moisture and flame resistant, and meets Federal Aviation Administration (FAA) regulations covering flame resistant aircraft materials. It has good thermal insulating properties because of its foam structure.

The tape is available in widths up to 6 in. and in lengths up to 8 ft. It sells for $1.55 per sq ft.

KEY NO. 620

***Applying** new polyurethane foam tape to an aircraft panel. The tape conforms to rough and irregular surfaces.*

Stainless Steel Resists Combustion Products

A new austenitic stainless steel, called No. 21-6-9, has been developed by Armco Steel Corp., Middletown, Ohio.

A big advantage of the new steel is its good resistance to attack by products of combustion, particularly from leaded gasolines. It also has superior resistance to oxidation at high temperatures.

Tough at subzero

Armco says the new grade of

why, oh why should a mold or die be made of Speer Graphite?

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IT HOLDS ITS SHAPE.
Does not distort or change dimension regardless of temperature, repeated heating and cooling, or thermal shock.

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For more information, circle No. 377

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Matte finish for molded parts**
- **Phenolic for blowers**
- **Fire-safe, bakable reinforced polyester**

NORTON LABORATORIES, INC.

Want less gloss?

For years we've trumpeted the virtues of the high gloss that's characteristic of phenolic molded parts.

Gloss, however, is not always a plus. In certain precision instruments, gloss translates into *glare*. Sometimes, too, a consumer product can gain esthetically from the satiny look and feel of a matte finish.

One custom molder, Norton Laboratories, Inc., has developed a special process for putting matte finishes on compression-molded phenolic parts, as on the double-duty lamp handle-switch above. In some instances, the finish takes the place of a painting operation and so lowers cost.

The plastic molder now supplying this type finish is Norton Laboratories, Lockport, N. Y. We suggest that you write to them directly for quotations on plastic parts you need incorporating this finish.

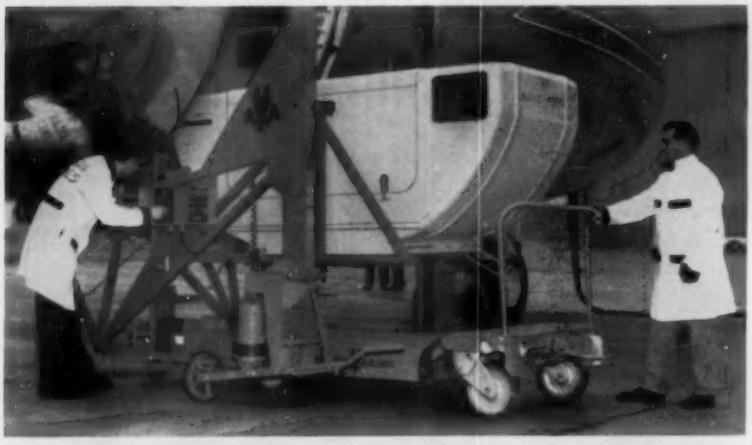
Move air at low cost

Note the economy of design in this blower and duct assembly for an automatic washer-dryer. Why use more pieces when three will do?

Note, too, how economy begets economy. Very few assembly operations. Few rejects, because these phenolic parts can't get bent and won't warp. No balancing needed in the blower wheel, because concentricity is molded in. Wobble is much less than could be achieved at low cost in a metal wheel.

Phenolic is functionally right for air-moving jobs, especially if they also involve heat: a small hair dryer, a big circulating fan, or just about anything between. Inexpensive general-purpose molding compound serves adequately, as a rule: withstands moisture and mild corrosive atmospheres; is unbothered by temperatures up to 300°F; even resists flame spread; operates for years without rattling, drumming.

Your molder of thermosetting plastics can probably help *you* achieve such economy, whether in a blower or some other part you're working on. To get more ideas on where and how to use phenolic molding compounds, send in the coupon, requesting Durez Bulletin D400.



The different polyester

Cutting across the currents and countercurrents of talk about reinforced polyester plastics are two incontrovertible facts:

1. You can get a polyester molding material that's *inherently and permanently self-extinguishing.*
2. This same polyester can take a baked-on finish without surface craze.

Its name is Hetron.® The self-extinguishing trait does not come about as a result of diluting the plastic's strength with additives. It's there to begin with, in atoms of chlorine welded tightly into the resin molecule. That's why it lasts.

So much for chemistry. The craze resistance takes longer to explain, but matched-die molders know they can count on it for structural shapes that must undergo a 90-minute bake at 350°F.

Superimpose these two truths on the other advantages of strong, lightweight polyester construction, and you can appreciate why Hetron is helping so many designers give shape to new ideas. This luggage pod for a jet airliner is one case in point. Others include 65-foot radomes, factory skylights, large boat hulls, outboard-motor shrouds, chemical ducts and vessels, transformer housings, heavy-duty switch-gear components.

If you'd like to know more about this versatile material, check the coupon for designer's Hetron data file.

For more information on Durez materials mentioned above, check here:

- ☐ Phenolic molding compounds (8-page Bulletin D400)
- ☐ "Durez Plastics News" (a review of current plastics applications, mailed bimonthly)
- ☐ Hetron polyester resin (data file and list of fabricators)

Check, clip and mail to us with your name, title and company address.
(When requesting samples, please use business letterhead)

DUREZ PLASTICS DIVISION

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HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

For more information, turn to Reader Service card, circle No. 398

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for electrical and magnetic uses

The many VASCO nickel-iron and silicon-iron powder alloys now available permit you to specify metal powder parts with magnetic properties exactly fitting your requirements. These prealloyed powders (alloyed by melting) enable significant reductions in lead time to full component production, frequent savings in cost, and interesting possibilities for miniaturization. For details on VASCO prealloyed powders, and names of fabricators of magnetic alloy parts, write us.

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VANADIUM-ALLOYS STEEL COMPANY

POWDER METALLURGY DEPARTMENT

LATROBE, PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 441

What's new IN MATERIALS

stainless steel has higher mechanical properties in the solution treated condition than standard grades of stainless steel. The alloy also has excellent strength and toughness at subzero temperatures. It is readily weldable, and is free from susceptibility to corrosion attack in the heat affected zone.

The new steel is produced in bar, wire, sheet, plate and strip.

KEY NO. 621

COMPOSITION OF NO. 21-6-9 (%)

Carbon	0.08 max
Manganese	8.0-10.0
Phosphorus	0.060 max
Sulfur	0.030 max
Silicon	1.0 max
Chromium	19.0-21.5
Nickel	5.5-7.5
Nitrogen	0.15-0.40

MECHANICAL PROPERTIES OF NO. 21-6-9*

Tensile Strength, 1000 psi	
Room Temperature	100
1200 F	58
Yield Strength (0.2% offset), 1000 psi	
Room Temperature	51
1200 F	19
Elongation (in 2 in.), %	
Room Temperature	75
1200 F	35
Reduction of Area, %	
Room Temperature	53
1200 F	45
Impact Strength (Charpy), ft-lb	
Room Temperature	>240
−100 F	>230
−320 F	115

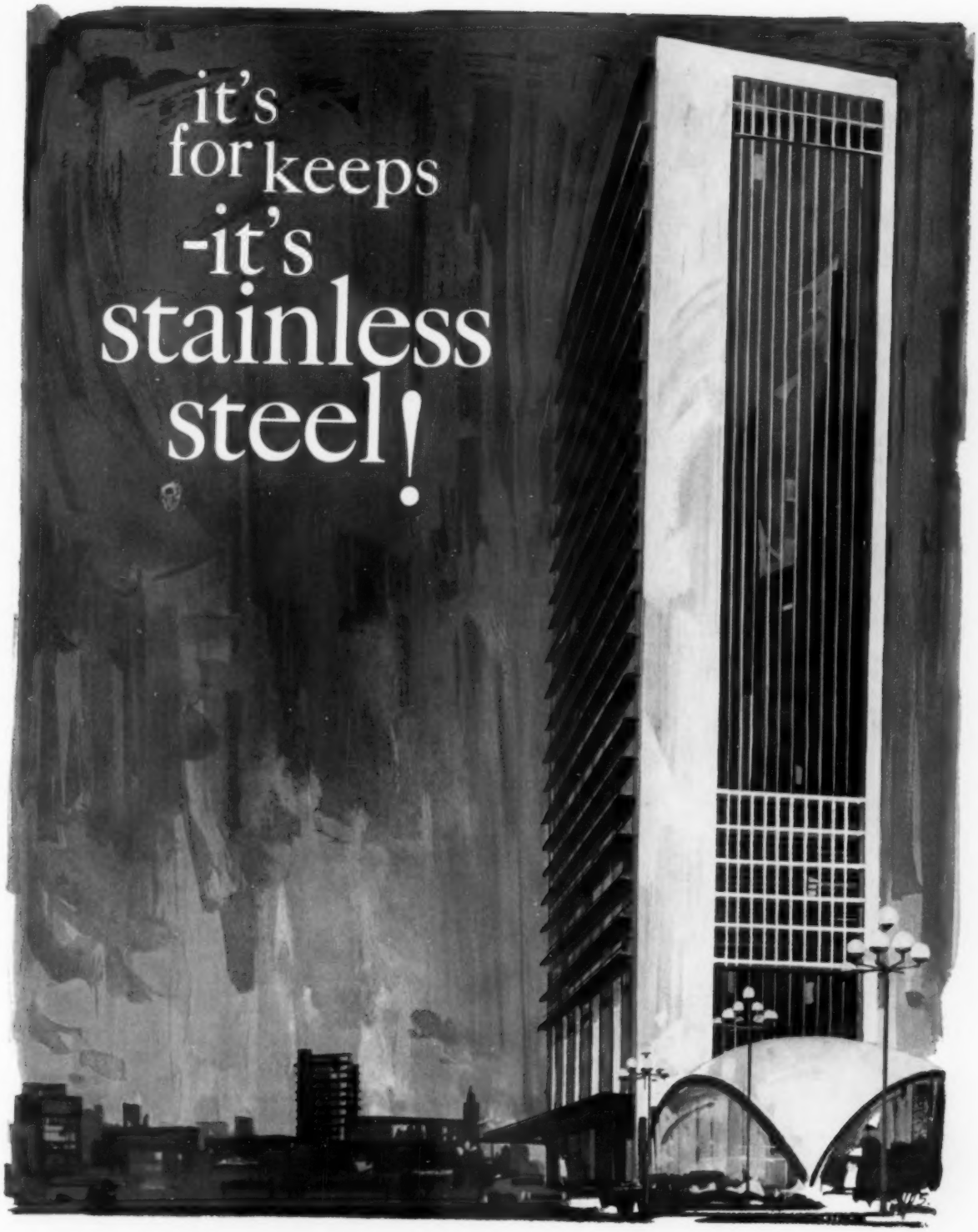
*Tests performed on 1-in. dia annealed round bar.

Coated Plastics Films Are Weather Resistant

Two new coated cellophane types of plastics films for packaging and nonpackaging applications are more durable under normal weather conditions and at below freezing temperatures than conventional cellophane films, recent tests show.

The films are now available in limited quantities from American Viscose Corp., 1617 Pennsylvania Blvd., Philadelphia 3. They are com-

For more information, circle No. 417 ➤



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Address_____

City_____ Zone____ State_____

Signature_____

Company and address_____

For more information, circle No. 440

What's new IN MATERIALS

posed of two light-gage cellulose base sheets with a thin polymer resin inner ply. Both are 450-gage films.

T-69 has an improved moisture-proof, heat sealing nitrocellulose coating on both surfaces. It sells for 98¢ per lb.

T-97 has a special polymer coating on both surfaces to give good heat sealing, moisture-proof and gas-proof characteristics. It sells for $1.10 per lb. **KEY NO. 622**

Foam Plastics Resist Oil, Gasoline, Acids

Three new developments in insulating foam plastics have been announced recently by Dow Chemical Co., Midland, Mich. They are: 1) a rigid urethane foam board with good solvent and chemical resistance, 2) a polystyrene foam board with flame retardant properties, and 3) a styrene-acrylonitrile foam with good resistance to gasoline and oil.

1. Rigid urethane foam

Dow's rigid urethane foam board, called Thurane, has good resistance to gasoline, ethyl alcohol, 10% hydrochloric acid, diesel and motor oils, kerosene, 10% sulfuric acid, toluene, benzene, water, brine, perchloroethylene, and concentrated solutions of sodium hydroxide. The foam also has low thermal conductivity and high heat distortion. It is

***New polystyrene foam** extinguished itself in less than 5 sec after exposure to intense gas flame.*

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*temperature indicating crayons**

**Also Tempil° Pellets and Tempilaq° (liquid form)*

***Tempilstik°*—a simple and accurate means of determining preheating and stress relieving temperatures in welding operations. Widely used in all heat treating—as well as in hundreds of other heat-dependent processes in industry. Available in 80 different temperature ratings from 113°F to 2500°F . . . $2.00 each.**

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For more information, circle No. 324

New from Du Pont—

FABRICS COATED WITH

VITON®

A synthetic compound that resists abrasion, corrosion, oils, solvents, temperature extremes

There are new opportunities for coated fabrics when durable "Viton"* synthetic rubber is combined with fabrics of glass, "Armalon"* TFE-fluorocarbon resin-coated glass, "Dacron"* polyester fiber, or "Teflon"* TFE-fluorocarbon fiber.

For example, a glass fabric coated with "Viton" and laminated to Refrasil fabric ("Fairprene"* 85-002) for use as a missile screen, when exposed for 60 seconds to 5700°F., 1½ inches from the surface, shows only slight charring of the Refrasil and practically no effect on the "Viton" coated glass which forms the alternate side of the laminate. "Viton" maintains its elastomeric properties despite this heat...can also withstand temperatures as low as minus 40°F., in gauges up to .020", without cracking.

An "Armalon" fabric coated on one side with "Viton" has proved promising as a tubing for transporting corrosive gases. These tubes can be heat-sealed on the "Armalon" side, with "Viton" on the outside, assuring excellent resistance to heat and chemicals as well as low permeation loss of the gases.

Fabrics coated with "Viton" are available for experimentation, test runs, or full-scale production operations. Contact your nearby Du Pont "Fairprene"* representative for complete information, or send coupon at right for literature and information.

*Du Pont registered trademarks.

PHYSICAL PROPERTIES OF FABRICS COATED WITH "VITON"

	86-007	85-001	84-001
Description: Polymer Fabric	"Viton" A "Teflon"	"Viton" A #116 Glass	"Viton" A "Dacron"
Properties: Gauge	.020"	.011	.008"
Wgt., Oz./Sq. Yd.	22	15	9
Tensile Strength Strip, Lbs./Inch, W x F	77 x 73	117 x 90	81 x 70
Tear Strength Trap., Lbs. W x F	16 x 13	1 x 1	2 x 3
Abrasion Resistance 1 Lb. Edgewear Strokes	10,000	10,000	10,000
Burst Strength, Mullens, PSI	168	172	158
Gehman Stiffness T10* °F.	3°	3°	3°

*Temperature at which it is 10 times as stiff as at 77° F.

Du Pont Industrial Coated Fabrics

DU PONT
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Fabrics Sales, Dept. MD-14, Wilmington 98, Delaware.

Please send literature on fabrics coated with Du Pont "Viton" synthetic rubber.

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*Company*_____

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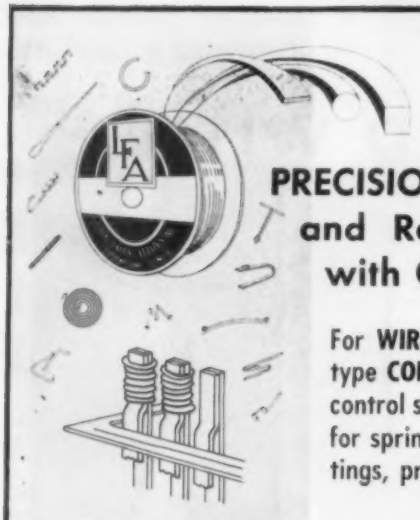
For more information, turn to Reader Service card, circle No. 439



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For **WIRE-WRAP** and **PLUG** or **PIN** type **CONNECTORS** for computors, control systems, missiles, etc., Also for springs, terminals, forms, fittings, prongs, contacts and clips.

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Square and rectangular shaped wires are frequently used in modern "wrapped" terminal and pin or plug type connectors. For this application the edges must be finished quite sharp (usually .003 radius corners or less) but without a burr or flashing. Also required are **closely controlled dimensional tolerances** and smooth finish. Uniformity of temper is essential. Therefore close control of all facets of wire manufacturing is of paramount importance.

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Standard Diam.
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Open and closed end with either standard or full diameter *integral washer bases*. 15 hex sizes: 1/4" - 15/16". #4-36 to 5/8" - 18 threads. Wide range of regular Cap Nuts . . . stock styles, types, sizes and threads.

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• High in quality stock styles, types,
• Low in cost sizes and threads

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For more information, turn to Reader Service card, circle No. 404

made from polyethers and toluene diisocyanate and is expanded with a fluorocarbon blowing agent.

Other properties of the rigid urethane foam board are given in an accompanying table.

The rigid urethane foam board is expected to be used as a core for sandwich panels and as a thermal insulation for trucks, pipes, railway cars and tanks. It is also expected to be used for buoyancy applications.

The foam burns if adequate air is available for combustion. However, Dow says the foam does not constitute a fire hazard when installed between noncombustible materials such as metal skins. The surface of the foam deteriorates in the presence of sunlight, but conventional protective coatings will eliminate this problem.

The foam board is supplied in lengths from 48 to 108 in., widths from 24 to 48 in., and thicknesses from ¾ to 16 in. **KEY NO. 623**

2. Polystyrene foam

The flame-retardant polystyrene foam is designed as a building insulating material. Tests conducted in accordance with ASTM D1692-59T show the foam is self-extinguishing after exposure to an intense gas flame. Called Styrofoam, the material replaces Dow's previous flame-retardant polystyrene foam called Styrofoam 33, introduced in 1952. The newer polystyrene foam is said to have better light stability and higher heat distortion than Styrofoam 33. It is colored blue.

The foam is available as boards

PROPERTIES OF THURANE

PHYSICAL PROPERTIES	
Density, lb/cu ft	1.8-2.3
Ther Cond (70 F), Btu/hr/in./sq ft/°F/in.	0.16-0.17
Water Absorption (48 hr), %	1.2-2.0
Flash Ignition Temp, F	590
Heat Distortion Point, F	250
MECHANICAL PROPERTIES	
Compr Yld Str, psi	30-50
Compr Modulus, psi	800-1200
Flexural Strength, psi	40-60
Flexural Modulus, psi	650-1000
Shear Strength, psi	20-28
Shear Modulus, psi	300-500
ELECTRICAL PROPERTIES	
Dielectric Constant (10^6 cps)	1.04
Dissipation Factor (10^6 cps)	0.0013

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Select a brazing alloy "tailored" to your precise requirements from the complete line of Silvaloy Low Temperature silver brazing alloys and fluxes. Silvaloy bond is as strong or stronger than the metals joined...available in wire, coil, strip, plymetal or preformed shape most convenient and economical for your production procedure. • Silvaloy is used by the country's leading manufacturers to speed and simplify production, to assure highest quality work, at lowest cost. Write for literature.

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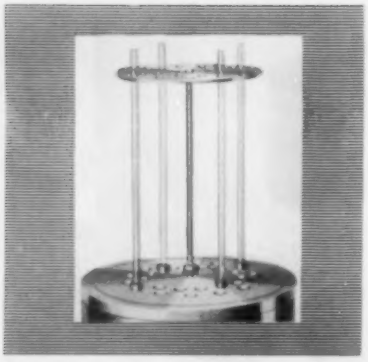
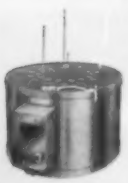


ENVIRONMENTAL TESTER FOR ELASTOMERS

SCOTT MODEL LG Aluminum Block Oven is the choice of the modern laboratory for high temperature air or oil immersion aging of rubber, silicone, and other elastomeric materials, in accordance with ASTM Method D865 or D471. In addition to the standard ventilating tubes required by D865, Model LG is also available with "umbrella" support and 30" reflux tubes required by changes in D471 (see D471-59T). Twenty-eight separate test compartments insure contamination-free testing, and afford ready access to each compartment at any time.

PRECISE TEMPERATURE CONTROL—Built-in electrical heating elements and manually set thermostatic controls provide precise temperatures up to 600°F within ± 1°F. The Model LG aluminum block is fully insulated to minimize temperature variations. High-low range selector switch on control box, and thermo-regulator switch on top of unit offer simple, finger-tip control of test temperatures.



CLEANER, SAFER—Tester has machined aluminum block with precision compartments to receive removable test tubes. No heating medium vapors. No fire hazard at elevated temperatures. No problems of heating medium residue on outside of test tubes.

FOR COMPLETE FACTS on the Scott Model LG with attachments for immersion testing, or standard Model LG for test tube aging, write to Scott Testers, Inc., 65 Blackstone St., Providence, R. I. Tel. DExter 1-5650 (Area Code 401).

SCOTT TESTERS

THE SURE TEST . . . SCOTT!

For more information, circle No. 437

9 ft long and 16 in. wide. Thicknesses range from 1 to 4 in. **KEY NO. 624**

3. Styrene-acrylonitrile foam

The new styrene-acrylonitrile foam, called Tyrilfoam, is designed for buoyancy applications in boats and in floating structures that are exposed to a combination of oily water and heavy gasoline spillage. General purpose polystyrene foam is only moderately resistant to gasoline and oil. The foam is supplied as boards 18 in. wide by 9 ft long. Thicknesses range from 8 to 12 in. **KEY NO. 625**

Synthetic Rubber Has Good Color Stability

A new styrene-butadiene (SBR) synthetic rubber with excellent color stability and good physical properties has been introduced recently by

PROPERTIES OF PLIOFLEX 1510*

ORIGINAL PHYSICAL PROPERTIES	
Tensile Strength, psi	4000
Elongation, %	480
Shore Hardness	A71
Crescent Tear Strength, psi	284
AFTER AGING 70 HR AT 158 F	
Retained Ten Str, %	89
Retained Elongation, %	80
Shore Hardness Chg, pts	−1

*Tests conducted on HAF black formulation cured 45 min at 305 F.

***Typical use** for Goodyear's new synthetic rubber is kneeling pads here being molded in the plant of Rubbermaid, Inc., Wooster, Ohio.*

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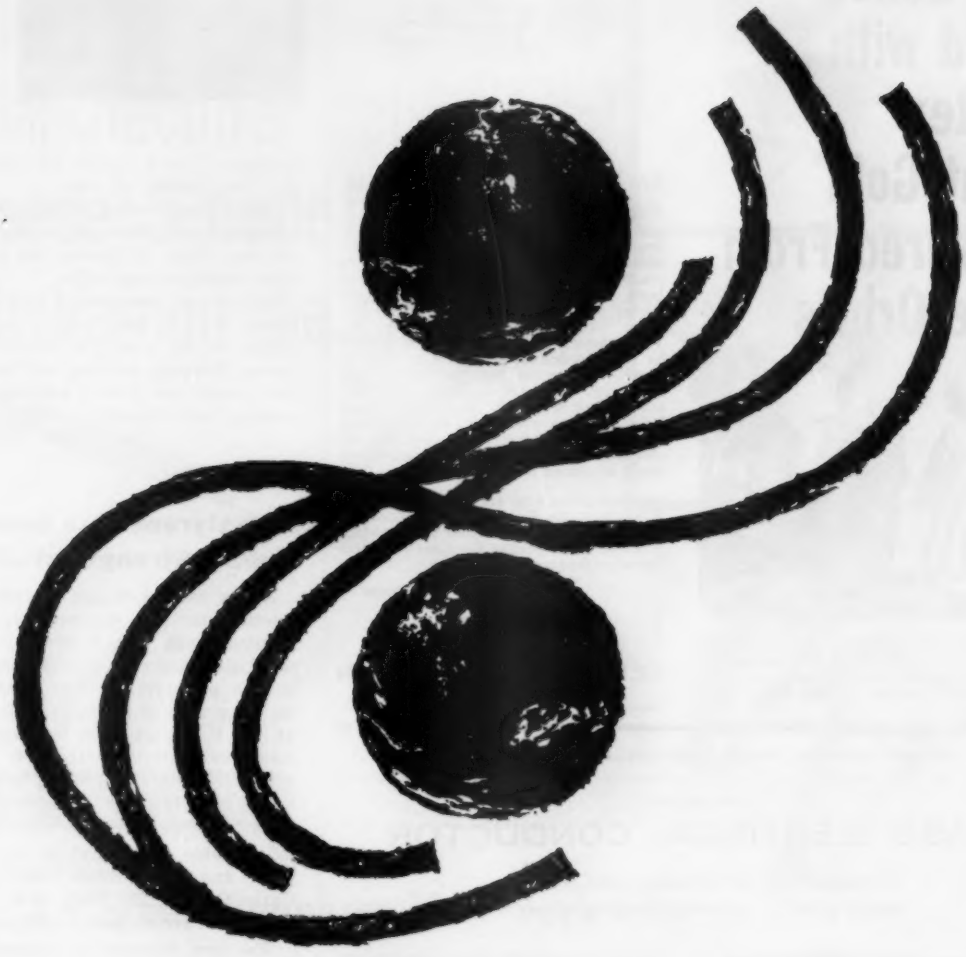

Said Johann Kepler: *"The planets move in elliptical orbits about the sun, and the square of their periods of revolution are proportional to the cube of their mean distances from the sun."*

With interplanetary voyages fast becoming a reality, complete information regarding the velocity requirements for travel between planets is of vital importance. With these data available, it is possible to analyze propulsion requirements, plan ultimate system configurations, and conduct feasibility studies for any particular mission.

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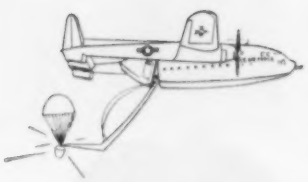
President Eisenhower holds American flag which was in recovered capsule during its flight through space. Capsule shown was electroplated with patented Sel-Rex Bright Gold Process.



finding the golden needle in the haystack...

Space capsule Discoverer XIV was plated with Sel-Rex Bright Gold. So was its predecessor, Discoverer XIII, which had been rescued earlier from the Pacific Ocean.

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For more information, turn to Reader Service card, circle No. 343

What's new IN MATERIALS

Goodyear Tire & Rubber Co., Chemical Div., Akron 16, Ohio.

The rubber, called Plioflex 1510, has good mold flow and is easy to process. Other properties are given in an accompanying table.

Because of its excellent color stability, the synthetic rubber is expected to be used for closed cell sponge, flooring, sporting and household goods, and related products requiring high color standards.

KEY NO. 626

Polystyrene Has Good Impact Strength at -20 F

A new medium-impact polystyrene injection molding compound is said to have much higher strength and toughness than conventional medium impact polystyrenes. For example, ball drop tests of moldings conducted at –20 F and at room temperature show the material withstands four times as great a blow as conventional medium impact specimens.

The compound called TMD-9020, is available in natural as well as pastel and opaque colors from Union Carbide Corp., 270 Park Ave., New York 17. Current price is 26¢ per lb.

The new material is expected to be used in thin-walled products.

KEY NO. 627

Rigid Foamed Plastic Resists Deformation

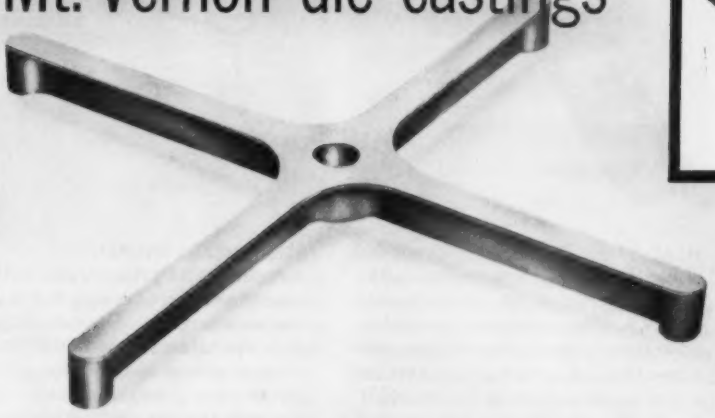
A rigid foamed plastic material is designed as a load-bearing pipe insulation on deeply buried underground lines and other areas where pipe covering may be subject to compression set deformation.

The new material, called Rigid Armaflex, is available from Armstrong Cork Co.'s Insulation Div., Lancaster, Pa. It is furnished in prematched half sections 3 ft long, in ½ and ¾-in. thicknesses.

The material, of undisclosed composition, is recommended for use on liquid cooling and heating lines, chilled water lines, and other cold lines in plumbing, heating, air conditioning, refrigeration, and industrial processing equipment.

The rigid foamed plastic is im-

Steel furniture manufacturer gets **these 5 benefits** from Mt. Vernon die castings



CASE HISTORIES FROM MT. VERNON FILES

Subject:

Art Steel Company, New York City

In a major switchover, Art Steel Company makes this handsome Steelmaster Desk with aluminum die cast legs. The companion Executive Chair stands on a die cast aluminum base. Formerly it took 8 parts to assemble each island leg of the desk . . . and 14 parts for the chair base. But switching to die cast parts gave Art Metal Company 5 major benefits:

1. Simpler fabrication since all castings are one-piece integral units. No more multiple section subassembly work.

2. Complete freedom in designing due to the many inherent advantages of the die casting process.

3. Corrosion of legs and bases caused by office cleaning detergents no longer a problem. Aluminum die castings stay bright and attractive.

4. Die castings are delivered polished, drilled and tapped, ready for use. Several assembly steps previously required have been eliminated.

5. Because production of legs and bases has been put into Mt. Vernon, valuable production capacity at Art Steel has been freed for other requirements.

More and more, in a great variety of products, Mt. Vernon Die Castings are replacing complex sheet metal assemblies and costly, crude sand castings, bringing significant production economies to the manufacturer. All the knowledge we have gained on this subject is also available to you . . . free. Why not discuss your problem with us too. A call to your nearest Mt. Vernon representative will bring you action.

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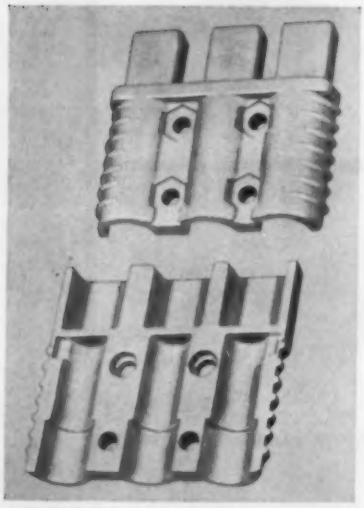
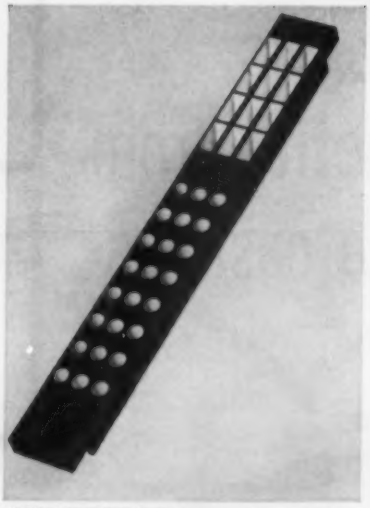
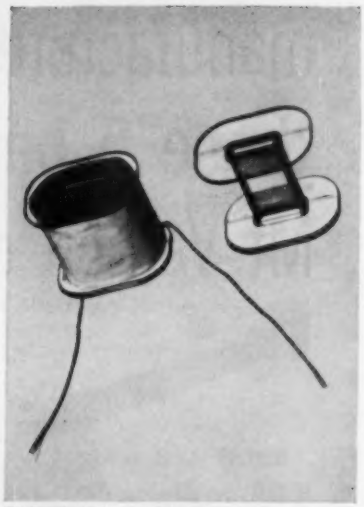


STRENGTH LEXAN resin has an impact strength of more than 12 foot-pounds per inch of notch — higher than any other plastic! This toughness, plus heat resistance and good electrical properties, make LEXAN resin an outstanding choice for 3-pole connectors used in rugged service on electric trucks.



HEAT STABILITY Lampholder terminal block is used inside electronic equipment where heat is difficult to dissipate. LEXAN polycarbonate resin replaced another thermoplastic which melted under severe thermal conditions. LEXAN has a heat distortion point as high as 290°F. Also keeps high strength in sub-zero cold.



ELECTRICAL PROPERTIES A good dielectric, LEXAN resin is non-corrosive even when used with very fine Class F magnet wire. Coil forms must not distort at temperatures above 200°F under stresses caused by tightly wound wire. LEXAN resin provides high heat distortion temperatures under load.

---

pervious to moisture vapor, dimensionally stable, self-extinguishing and ozone resistant. **KEY NO. 628**

Other News . . .

Metals

▸ An improved tantalum powder for capacitors is said to offer high capacitance and good processability. Designated SGP, the powder is available from National Research Corp., 70 Memorial Dr., Cambridge 42, Mass. **KEY NO. 629**

Plastics

▸ A new vinyl dispersion resin for high quality coating and molding applications is available from Union Carbide Plastics Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17. The resin, called QXKV-2, is particularly well suited for slush and rotational molding of intricately shaped parts such as toys and sporting equipment. **KEY NO. 630**

▸ Electrical-grade nylon rods are available in diameters from ¼ to 3 in. from A. L. Hyde Co., Grenloch, N. J. The electrical-grade nylon (Zytel 31) is said to have lower moisture absorption and better dimensional stability than general purpose nylon. **KEY NO. 631**

▸ A two-component liquid epoxy resin is recommended for impregnating and encapsulating electrical and electronic parts. The resin, introduced by Hysol Corp., Olean, N.Y., is said to have excellent electrical properties and good resistance to thermal and mechanical shock. **KEY NO. 632**

▸ Two new plastics casting resins have been introduced recently by Melpar, Inc., 3000 Arlington Blvd., Falls Church, Va. One resin, called Melpak E-200, is a general purpose epoxy potting, encapsulating and casting resin; the other, called Melpak P-200, is an unfilled polyester resin useful for potting and encapsulating electronic parts and for small castings. **KEY NO. 633**

▸ A polyvinyl chloride resin for calendered, injection molded and extruded products has been introduced by Goodyear Tire & Rubber Co., Chemical Div., Akron 16, Ohio. The resin, designated Pliovic S-75, is said to have excellent handling characteristics and good heat stability.

▸ Development of a new polyethylene compound with low loss electrical properties has been announced by Union Carbide Plastics Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17. The resin, called Bakelite DFDA-0173, is designed primarily for electrical insulation on cables. **KEY NO. 634**

▸ A new polyester laminate introduced recently by Irvington Div., Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul, Minn. is said to provide improved varnish-to-film adhesion, eliminating voids and gaps which encourage moisture attack within impregnated and encapsulated units. The laminate, called No. 2541, is sold in thicknesses from 0.007 to 0.015 in. **KEY NO. 635**

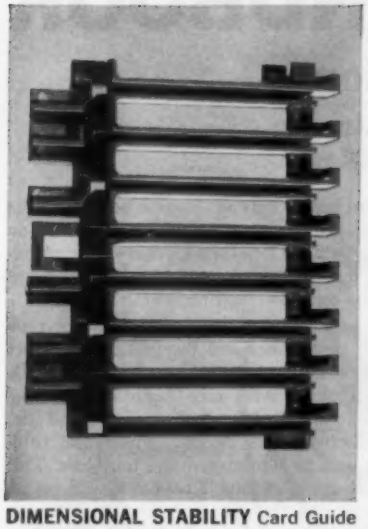
SOURCES *of most engineering materials can be found in M/DE's Materials Selector Issue, published last November.*

Other nonmetallics

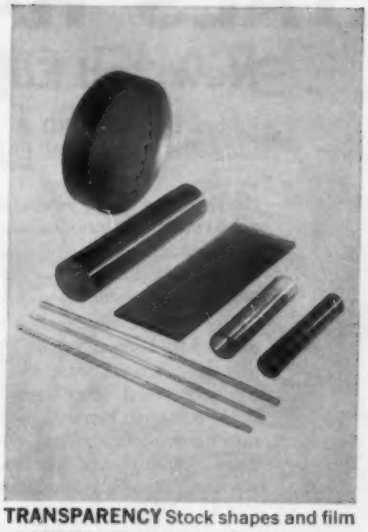
▸ Metallized ceramic disks in diameters from 0.020 to 0.500 in. and in thicknesses from 0.008 to 0.050 in. are available from Mitronics, Inc., 1290 Central Ave., Hillside, N. J. The ceramic parts are made from 96% alumina, metallized on one or both sides with molybdenum-manganese and plated with nickel, copper or gold. **KEY NO. 636**

▸ Three crushable ceramics for use in metal-sheathed heaters, cables,

BONATE RESIN TOUGHEST OF PLASTICS!



DIMENSIONAL STABILITY Card Guide for business machines is molded to close tolerances . . . must undergo minimum change in dimensions during service. Parts show excellent dimensional stability under moist and high temperature conditions. LEXAN resin meets self-extinguishing requirement.



TRANSPARENCY Stock shapes and film of LEXAN polycarbonate resin have excellent transparency. Bar stock is easily machined; film can be thermoformed, heat-sealed and solvent-sealed. Combination of clarity, toughness and malleability gives LEXAN resin the design capabilities of a transparent metal!

LEXAN OPENS UP NEW OPPORTUNITIES... Even before LEXAN entered large-scale production, manufacturers, impressed by its exceptional properties, developed and field tested over 300 applications. G.E. participated in these developments. With the opening of new G-E facilities capable of producing millions of pounds of LEXAN per year, the price of this versatile thermoplastic has dropped dramatically — over 40% in a single year. This fact alone has brought many new products within the range of feasibility. Can you afford to overlook the opportunities presented by LEXAN? Send for details on price, properties, applications and G-E's technical assistance program today! General Electric, Chemical Materials Department, Section M-41, Pittsfield, Mass.

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thermocouples and electric range units are available from American Lava Corp., Manufacturers Rd., Chattanooga 5, Tenn. The ceramics are supplied as tubes 1 to 4 in. long. The tubes form a dense ceramic insulation when swaged inside a metal sheath. KEY NO. 637

▸ Silicone-impregnated glass-asbestos paper now available from Raybestos-Manhattan, Inc., Asbestos Textile Div., Manheim, Pa. is said to have excellent resistance to heat, water and corrosion. Called Style No. 7527, the paper is sold in the form of sheets, rolls and tape. KEY NO. 638

▸ Glass-bonded mica substrates for printed circuit applications are marketed by Electronic Mechanics, Inc., Clifton, N. J. The substrates, called Mykroy, consist of small glass-bonded mica slabs with leads molded in position. KEY NO. 639

Finishes

▸ Newly developed porcelain enameled nameplates can be bent, formed, cut, drilled and stamped without damaging the porcelain enamel finish. The nameplates are available from Erie Ceramic Arts Co., 3120 W. 22nd St., Erie, Pa. KEY NO. 640

▸ An epoxy coating for interior applications is said to cure to a smooth, glossy, tile-like finish that will not wear, fade, flake or chip after repeated washings. Designated Epo, the coating is marketed by George E. Fines, Inc., 18640 Wyoming Ave., Detroit 21. KEY NO. 641

▸ A new cleaning compound has been designed especially for removing heavy and tenacious soils from steel, brass and magnesium by tank immersion techniques. Called HD 126, the compound is available from Oakite Products, Inc., 19 Rector St., New York 6. KEY NO. 642

▸ A strippable vinyl coating protects polished metal surfaces against marring and scratching during fabrication, storage and shipping. It also protects metal surfaces from the effects of oil and grease. The coating, called Strip-Gard, is available from Stoner-Mudge Co., Div. of American-Marietta Co., Pittsburgh. KEY NO. 643

Joining, fastening

▸ Java-Flok is the name given to a flame resistant flocking adhesive designed for decorating toys, novelties, displays and plaster ornaments. It is available from Java Latex and Chemical Corp., 1713 West Farms Rd., New York 60. KEY NO. 644

▸ A new series of adhesives for vinyl-metal laminates has been announced by National Starch and Chemical Corp., 730 3rd Ave., New York 17. Tradenamed Vy-Metal, the adhesives have high bond strength. KEY NO. 645

▸ A silver brazing flux for torch, furnace and induction brazing of stainless steel, nickel alloys, copper, brass, bronze, beryllium copper and silver alloys has been introduced by All-State Welding Alloys Co., Inc., 249-55 Ferris Ave., White Plains, N. Y. A major feature of the new flux, called S-200 Brazaloy, is unlimited shelf life. KEY NO. 646

▸ A two-part, solvent-free epoxy adhesive is recommended for applications where it is impractical to apply heavy pressure or heat for hardening. The adhesive, designated Maraset No. 533A, is marketed by Marblette Corp., 37-31 30th St., Long Island City 1, N. Y. It is intended primarily for bonding aluminum, steel, brass, copper, magnesium and combinations of these metals. KEY NO. 647

▸ A two-part, solvent-free epoxy adtate, polystyrene, vinyl and polyethylene blister packaging has been announced by Adhesive Products Corp., 1660 Boone Ave., New York 60. The water-base adhesive is called Blis-Stix. KEY NO. 648

Revised, expanded and brought completely up-to-date!
Provides latest data on 55 rare metallic elements . . .

RARE METALS HANDBOOK

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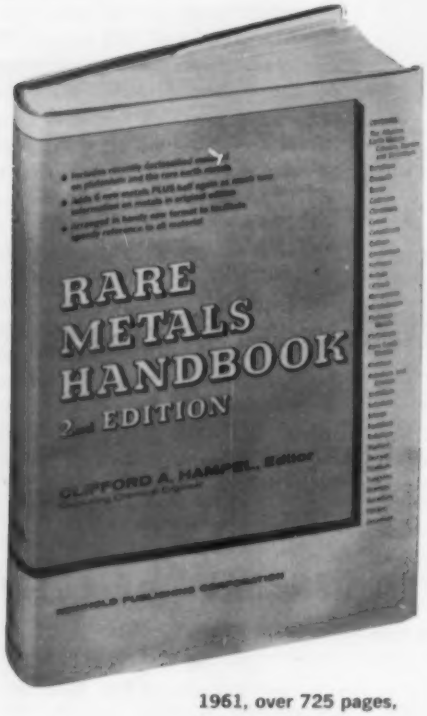
Edited by **CLIFFORD A. HAMPEL**
Consulting Chemical Engineer



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HERE IS A REVISED, expanded and completely up-to-date edition of the only volume on rare metals that provides engineering information on so many important structural materials. Compiled by forty-four recognized authorities, this valuable handbook presents the full range of currently available data on 55 of the less-common metals.

For this edition, six essentially new metals are added to those covered in the first edition, incorporating the studies and production processes that have come from the Ames Laboratory (Institute for Atomic Research) and other agencies working with rare earth metals. The book presents recently declassified material on plutonium and the rare earth metals, along with discussions of cesium, chromium, rubidium, scandium and yttrium, as well as columbium and tantalum. This second edition also includes half again as much new material on all metals in the original edition, covering the numerous recent advances in the field as well as the growing volume of data about the engineering properties of many of these metals.

Accurately and clearly written, each chapter of the book contains a convenient summary of current information on its topic. A handy new format facilitates speedy reference to such important aspects as occurrence, production statistics, economics, derivation, alloys and applications. A large amount of comparative data is included, such as the latest methods of production from ores or other raw materials, the chemical and physical properties of the metals, fabrication techniques, and present and potential uses. Properties and comparisons between metals are shown in convenient tabular form wherever possible, and complete and carefully prepared reference lists close every chapter.

This is a truly definitive guide to the less-common industrial metals that are playing such an increasingly important role in modern technology. Every chemist, metallurgist and engineer dealing with the production or application of any of these newer metals will want this important book on his desk or his reference shelf at all times.

CONTENTS: The Rare Metals — The Alkaline Earth Metals: Calcium, Barium, and Strontium — Beryllium — Bismuth — Boron — Cadmium — Chromium — Cobalt — Columbium — Gallium — Germanium — Hafnium — Indium — Lithium — Manganese — Molybdenum — Platinum Metals — Plutonium — Rare Earth Metals — Rhenium — Rubidium and Cesium — Scandium — Selenium — Silicon — Tantalum — Tellurium — Thallium — Thorium — Titanium — Tungsten — Uranium — Vanadium — Yttrium — Zirconium — Physical Properties of Metals.

SOME OUTSTANDING FACTS ABOUT THIS SECOND EDITION

- Includes recently declassified material on plutonium and the rare earth metals
- Adds 6 new metals PLUS half again as much new information on the metals included in the original edition
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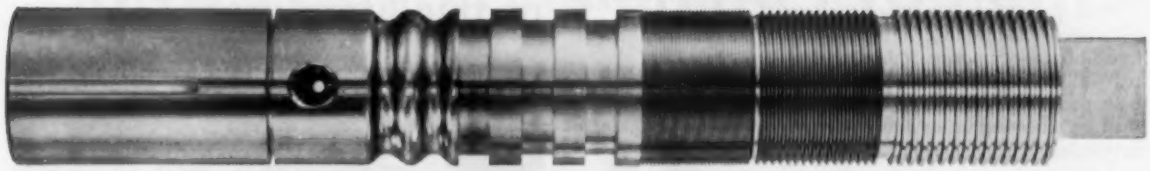
THEY LAUGHED WHEN WE SAT DOWN TO PLATE...

they didn't know about KANIGEN®



This shaft was turned. It was key-slotted, drilled, tapped and shouldered. It was threaded, milled, grooved and chamfered. It was step-bored, with three inside diameters. Who could plate a piece like this all over—inside and out—and expect a uniform coating?

Well, anyone who used KANIGEN® could expect it—and get it. In fact, we made this piece especially to prove it.

The KANIGEN® process for chemical nickel alloy plating produces a uniform thickness of coating, regardless of the contours of a part. This uniformity permits full machining operations prior to coating, with no subsequent cleanup.

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Spaulding **FIBRE FACTS FOR ENGINEERS** NUMBER 4

How to Punch Vulcanized Fibre to Reduce Fabrication Costs

by K. H. Alverson, Product Standards Director

Vulcanized Fibre's capacity for easy punching makes this material highly attractive to the designer whose application calls for characteristics such as good dielectric strength, light weight, rugged strength, irregular contours and holes and indentations in the surface of a part.

Punching is done with two kinds of precision: Rough punching uses the lowest cost solid dies, is rapid and economical, but leaves a fractured raw edge and is limited to stock thicknesses through ¼ in.; smooth shaving uses a contour die ground to a sharp edge that slopes away at 45°. The edge shaves stock when the part is forced into the die producing smooth edges in parts up to 1 in. thick. Holes can be punched easily, but should be generally spaced from each other and from any edge by at least the thickness of the stock. Noncircular holes and counterbores should be made circular for machining when the stock thickness specified is too thick to punch.

For thickness under 3/64", vulcanized fibre can be punched most economically with steel rule dies. Dies for simple parts usually cost much less than solid dies even for irregular contours. Tooling for scoring or creasing can also be added with little additional cost.

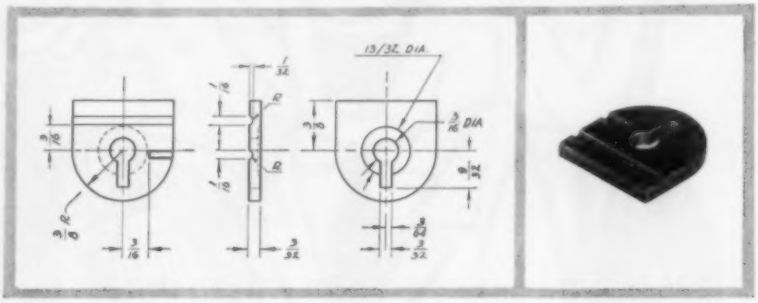
Most parts can be punched without additional conditioning if the vulcanized fibre has its normal moisture content of 5½ to 7%. For especially difficult punchings, or for parts thicker than ⅛", heating up to 200°F may be desirable.

Additional economies may be obtained in thicknesses 1/16" and under by using coils slit from parent rolls, reducing waste of stock, speeding up the punching operation, and reducing inspection costs.

Many extras may be incorporated in punching operations on vulcanized fibre. These include scoring or creasing for subsequent forming along established lines. Also practical are swaging or forming into special shapes, such as shoulder bushings or angles.

Stamping letters and numerals into the surface of vulcanized fibre in the punch-press operation produces permanently legible markings with no increase in cost of the part. White or colored roll leaf characters can also be impressed into the surface to give color contrast at very little added cost. Punched parts are also readily printed with rubber stamp.

Spaulding Engineers who have been trained in Value Analysis can help you take advantage of the wide range of possibilities in designing to reduce costs through the use of vulcanized fibre parts. They also make available to you Spaulding's extensive fabricating facilities and experience in working with this extraordinary material.



The fabrication of this shut-off switch insulator demonstrates vulcanized fibre's facility for punching and swaging. Previously moulded out of nylon, the part is now made by swaging both sides and punching vulcanized fibre — all in the same operation and at lower costs both for material and processing.

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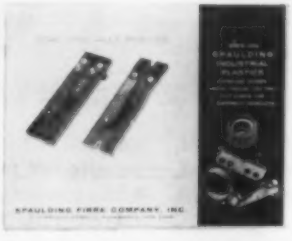

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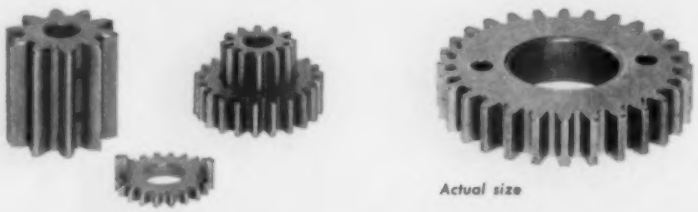

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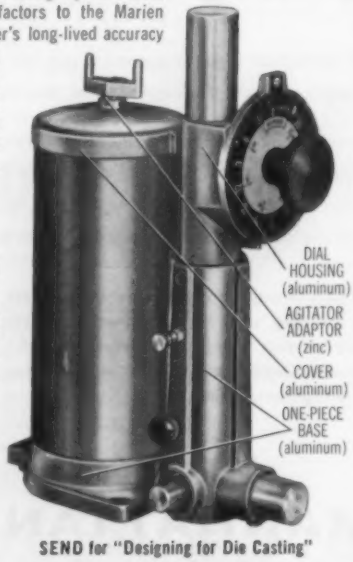

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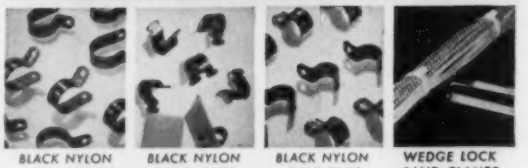

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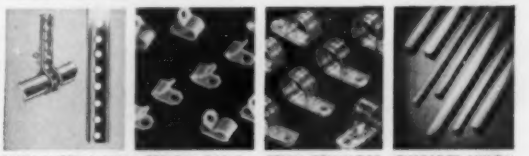

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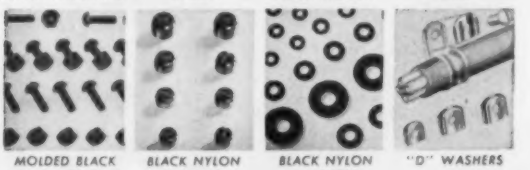

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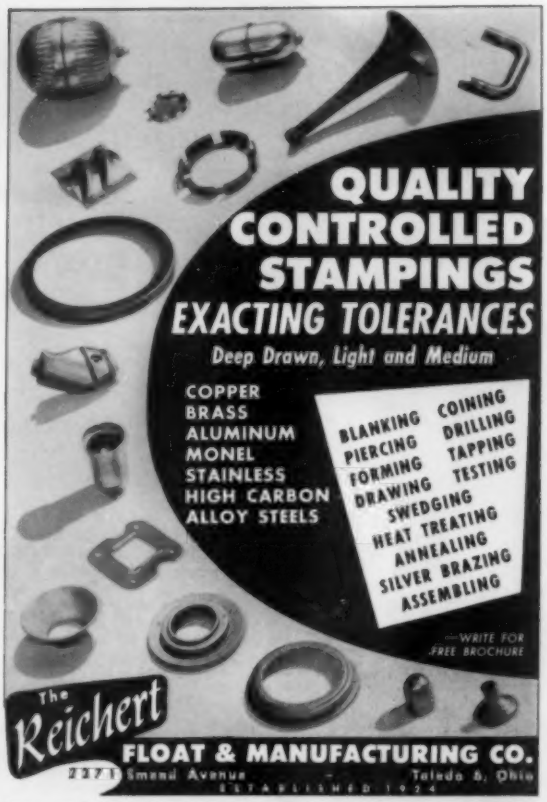

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For free technical literature on all kinds of engineering materials, forms and finishes, see pp 45-49.

PAGE NOS.

Adhesives 26, 189
Beryllium and its alloys 165
Books, technical 168, 176, 180, 186
Brazing alloys 108, 179
Carbides 63
Carbides, cemented 164
Carbon, graphite .. 88, 90, 156, 172
Casting alloys 2, 163, 191
Castings 172
Ceramic mold 152, 161
Die 2, 183, 190, 196
Investment 146
Shell mold 148
Ceramics 153
Ceramoplastics 30
Clad metals 157
Cleaners, metal 160
Coatings
Ceramic 94
Chemical conversion 76-77
Diffusion 150
Electroless nickel 187
Galvanized 80-81
High temperature 88, 147
Sodium nitrite 171
Vacuum deposited 88, 182
Copper and its alloys ... 92-93, 165
Corrosion resistant alloys ... 22
Diaphragms 27
Drawn, pressed parts 54
Extrusions, metallic .. inside front cover, 31
Fabrics, coated 27, 177
Fasteners, mechanical 38, 67, 178, 192
Ferroalloys 174
Finishing equipment 31
Glass 149
Heating equipment 192
Impact extrusions 104-105
Indium and its alloys 29
Iron, malleable 64-65
Laminates, plastics 28, 88, 110, 188, 194
Metal powder parts 72-73, 190
Metal powders 3, 55, 56, 58, 59, 71, 190
Nickel and its alloys 4, 60, 191
Perforated parts 136
Plastics
Acetals 84-85
Acrylic 167
Epoxies 106-107

PAGE NOS.

Fluorocarbons 154, 169
Laminates (see Laminates)
Phenolics 106-107, 173, 193
Polyamides (nylon) 33-34, 74-75, 159
Polycarbonate 184-185
Polyesters 173
Polyethylenes ... 39, 42, 106-107
Polypropylene ... 8, inside back cover
Polystyrene 42, 74-75, 106-107
Reinforced 88, 196
Urea 95
Vinyls 89, 102-103, 106-107
Vulcanized fibre 188
Plating processes, solutions .. 182
Precious metals 179
Precoated and preplated metals 18, 24
Pressure vessels 158
Quartz, fused 179
Refractory materials 78-79
Rubber
Foam 61
Silicone 101
Synthetic 6, 68-69
Urethane 50
Seals 144
Silicones 141-142
Stampings, punchings 194
Steel
Carbon 104-105
Heat and corrosion resistant 4, 104-105, 166, 174, 175, 191
Low alloy 104-105, 155
Specialty 86-87
Tool and die ..... outside back cover
Strip 20, 166
Temperature indicators 176
Testing equipment 180
Testing, ultrasonic 192
Tubing, pipe
Metallic 32, 51, 62, 82-83, 92-93, 161
Nonmetallic 154
Vacuum melted alloys 96, 151
Wire 36-37, 70
Wire, high temperature 59
Wood 66
X-ray film 91
Zinc and its alloys 195

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Use this index for the latest information on how and where to use **materials, forms and finishes** . . . because more companies advertise these products in the thirteen issues of MATERIALS IN DESIGN ENGINEERING than in any other magazine.

Aero Research Instrument Co. 59
Brandt Advertising Co.

Alan Wood Steel Co. 55
Aitkin-Kynett Co., Inc.

Allied Chemical Corp., Plastics Div. 97, 98, 99, 100
McCann-Erickson Advertising

***Allied Chemical Corp., Solvay Process Div.** 171
Kastor, Hilton, Chesley, Clifford & Atherton, Inc.

***American Cast Iron Pipe Co., Acipco Steel Products Div.** 161
Robert Luckie & Co., Inc.

***American Cyanamid Co., Plastics and Resins Div.** 95
Erwin Wasey, Ruthrauff & Ryan, Inc.

American Hot Dip Galvanizers' Association, Inc. 80, 81
Cahn, Miller & Strouse, Inc.

American Nickeloid Co. 18
Kenneth B. Butler & Associates

***American Smelting and Refining Co., Federated Metals Div.** 163
Ward William & Co.

Anaconda American Brass Co. .....2nd Cover
Kenyon & Eckhardt, Inc.

***AviSun Corp.** .....3rd Cover
Arndt, Preston, Chapin, Lamb & Keen, Inc.

Bean, Morris and Co. 172
Odiorne Industrial Advertising, Inc.

Bethlehem Steel Co. 67, 153
Hazard Advertising Co., Inc.

***Branson Instruments, Inc., Ultrasonic Test Div.** 192
Faulkner Advertising Inc.

***Brooks & Perkins, Inc.** 54
Clark & Roberts, Inc.

***Brush Beryllium Co.** 165
Meldrum & Fewsmith, Inc.

Carborundum Co., Refractories Div......78, 79
G. M. Basford Co.

Carpenter Steel Co. 96
Beaumont, Heller & Sperling, Inc.

***Celanese Polymer Co., Div. of Celanese Corporation of America** 84, 85
Ellington & Co., Inc.

Chicago Rawhide Manufacturing Co. 144
Aves, Shaw & Ring, Inc.

Chromalloy Corp. 150
Faulkner Advertising Inc.

Conforming Matrix Corp. 31
Wendt Advertising Agency

Continental-Diamond Fibre Corp., Sub. of Budd Co. 110
Aitkin-Kynett Co., Inc.

Coors Porcelain Co. 153
Galen E. Broyles Co., Inc.

***Corning Glass Works** 149
Rumrill Co., Inc.

Design Engineering Show, Clapp & Poliak, Inc. 40, 41
James R. Flanagan Advertising Agency

Dollin Corp. 196
Thoma & Gill

Dow Corning Corp. 141, 142
Church and Guisewite Advertising, Inc.

***du Pont de Nemours, E. I., & Co., Inc., Elastomer Chemicals Dept.** 50
N. W. Ayer & Son, Inc.

***du Pont de Nemours, E. I., & Co., Inc., Fabrics Div.** 177
Batten, Barton, Durstine & Osborn, Inc.

du Pont de Nemours, E. I. & Co., Inc. Film Dept. 169
Batten, Barton, Durstine & Osborn, Inc.

du Pont de Nemours, E. I. & Co., Inc. Polychemicals Dept. 33, 34
Batten, Barton, Durstine & Osborn, Inc.

***Duralay Co.** 148
Sanger-Funnell, Inc.

***Durez Plastics Div., Hooker Chemical Corp.** 173
Rumrill Co., Inc.

Eastman Kodak Co., X-ray Sales Div...... 91
J. Walter Thompson Co.

***Engelhard Industries, Inc.** 179
Stuart Sande Advertising

Enjay Chemical Co., Div. of Humble Oil & Refining Co. 8
McCann-Erickson Advertising

***Fairmont Aluminum Co., Sub. of Cerro Corp.** 157
Roche, Rickerd & Cleary, Inc.

Foster Grant Co., Inc. 74, 75
Donahue & Coe, Inc.

Gamble Brothers, Inc. 66
Doe-Anderson Advertising Agency, Inc.

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***General American Transportation Corp., Kanigen Div.** 187
Edward H. Weiss and Co.

General Electric Co., Chemical Materials Dept. 184, 185, 193
G. M. Basford Co.

General Electric Co., Silicone Products Dept. 101
Ross Roy-Brooke, Smith, French & Dorrance, Inc.

***General Extrusions, Inc.** 31
R. J. McCallister Co.

***Glidden Co., Chemical Divisions, Metals Dept.** 71
Meldrum & Fewsmith, Inc.

Goodrich, B. F., Chemical Co., Div. of B. F. Goodrich Co. 6, 102, 103
Griswold-Eshleman Co.

Goodrich-Gulf Chemicals, Inc. 68, 69
Griswold-Eshleman Co.

Goodyear Tire & Rubber Co., Chemical Div. 61
Kudner Agency, Inc.

Grace, W. R., & Co., Polymer Chemicals Div. 42
de Garmo, Inc.

Great Lakes Steel Corp., Div. of National Steel Corp. 86, 87
Campbell-Ewald Co.

Gries Reproducer Corp. 178
Harold Marshall Advertising Co., Inc.

***Handy & Harman** 108
Hazard Advertising Co., Inc.

Haynes Stellite Co., Div. of Union Carbide Corp. 22
J. M. Mathes, Inc.

***Hoeganaes Sponge Iron Corp.** 58
Norman A. Strang, Advertising

***Indium Corporation of America** 29
Farquhar and Co., Inc.

International Nickel Co., Inc. 4, 60, 191
McCann-Marschalk Co., Inc.

***Jones & Laughlin Steel Corp., Stainless and Strip Div.** 20
Palmer, T. N., & Co., Inc.

***Kennametal Inc.** 164
Ketchum, MacLeod & Grove, Inc.

***Latrobe Steel Co.** 151
McHenry-Derek Advertising

***Libbey-Owens-Ford Glass Co., Liberty Mirror Div.** 182
Fuller & Smith & Ross Inc.

***Little Falls Alloys Inc.** 178
Von der horst & Associates, Inc.

Lockheed Aircraft Corp., Missiles and Space Div. 181
Hal Stebbins Inc.

Macmillan Co. 176
J. M. Hickerson Inc.

Magna Manufacturing Co., Inc. 190
Gallard Advertising Agency, Inc.

***Malleable Castings Council** 64, 65
Carr Liggett Advertising, Inc.

Malone Metal Powders, Inc. 59

Materials in Design Engineering 162

Materials Selector 194

McLouth Steel Corp. 175
Denman & Baker, Inc.

***Metal & Thermit Corp.** 35
Marsteller, Rickard, Gebhardt and Reed, Inc.

***Metals Disintegrating Co., Div. of American-Marietta Co.** 56
Williams and London Advertising

Midland Industrial Finishes Co. 147
Western Advertising Agency

Minnesota Mining and Manufacturing Co., Adhesives, Coatings and Sealers Div. ... 26
MacManus, John & Adams, Inc.

Misco Precision Casting Co., Div. of Howe Sound Co. 146
Wallace-Blakeslee, Inc.

Mobay Chemical Co. 52, 53
Smith, Taylor & Jenkins, Inc.

Mt. Vernon Die Casting Corp. 183
Reach McClinton & Co., Inc.

***Mycalex Corp. of America** 30
Kelly, Nason, Inc.

Narmco Materials Div., Telecomputing Corp. 196
McNaughton-Lawb, Inc.

National Plastics Exposition (Society of the Plastics Industry, Inc.) 170
G. M. Basford Co.

***National-Standard Co.** 36, 37
Marsteller, Rickard, Gebhardt and Reed, Inc.

New Jersey Zinc Co. 2, 3

***Norton Co., Refractories Div.** 94
Chirurg & Cairns, Inc.

***Oakite Products, Inc.** 160
Marsteller, Rickard, Gebhardt and Reed, Inc.

Ohio Seamless Tube Div., Copperweld Steel Co. 82, 83
Palm & Patterson, Inc.

Paramount Die Casting Co., Sub. of Talon, Inc. 190
Paxson Advertising Inc.

Parker Rust Proof Co. 76, 77
Fred M. Randall Co.

Pennsalt Chemicals Corp., Research Products Development Dept. 89
Aitkin-Kynett Co., Inc.

Pereny Equipment Co., Inc. 192
Wheeler, Kight & Gainey, Inc.

***Perforating Industries, Inc.** 196
Raymond/Nicholas Advertising

Phillips Chemical Co., Plastics Sales Div. ... 39
Lambert & Feasley, Inc.

Pressed Steel Tank Co. 158
Buchen Advertising, Inc.

Pure Carbon Co., Inc. 90
John Harder Fenstermacher, Inc.

***Raybestos-Manhattan, Inc., Adhesives Dept.** 189
Gray & Rogers

***Raybestos-Manhattan, Inc., Plastic Products Div.** 154
Gray & Rogers

***Reeves Brothers, Inc., Vulcan Div.** 27
Ketchum, MacLeod & Grove, Inc.

***Reichert Float & Mfg. Co.** 194
Wendt Advertising Agency

Reinhold Publishing Corp. 168, 180, 186

***Republic Steel Corp.** 104, 105
Meldrum & Fewsmith, Inc.

Revere Copper and Brass, Inc. 92, 93
Adams & Keyes Inc.

Rohm & Haas Co., Plastics Div. 167
Arndt, Preston, Chapin, Lamb & Keen, Inc.

Russell, Burdsall & Ward Bolt and Nut Co. 38
Marsteller, Rickard, Gebhardt and Reed, Inc.

St. Joseph Lead Co. 195
Emil Mark & Co., Inc.

***St. Regis Paper Co., Industrial Panelyte Div.** 28
Cunningham & Walsh Inc.

Scott Testers, Inc. 180
Horton, Church & Goff, Inc.

***Sel-Rex Corp.** 182
Bass and Co., Inc.

***Spaulding Fibre Co., Inc.** 188
Barber & Drullard, Inc.

***Speer Carbon Co.** 172
Hazard Advertising Co., Inc.

Spencer Chemical Co. 159
Bruce B. Brewer & Co.

***Stackpole Carbon Co.** 156
Harry P. Bridge Co.

***Superior Tube Co.** 32
Gray & Rogers

***Supermet Div., Globe Industries, Inc.** 190
Odiorne Industrial Advertising, Inc.

***Swedlow Inc.** 88
Willard G. Gregory & Co.

***Sylvania Electric Products Inc., Parts Div.** 70
Kudner Agency, Inc.

***Synthane Corp.** 194
Arndt, Preston, Chapin, Lamb & Keen, Inc.

Tempil Corp. 176
RAF Advertising Inc.

Timken Roller Bearing Co., Steel & Tube Div. .....Back Cover
Batten, Barton, Durstine & Osborn, Inc.

***Union Carbide Plastics Co., Div. of Union Carbide Corp.** 106, 107
J. M. Mathes, Inc.

United States Graphite Co. 72, 73
Price, Tanner & Willox, Inc.

Vanadium-Alloys Steel Co. 174
Downing Industrial Advertising, Inc.

Vascoloy-Ramet Corp. 63
E. R. Hollingsworth & Associates

Wallingford Steel Co. 166
William Schaller Co., Inc.

***Waukesha Foundry Co.** 152
Chandlers

Weckesser Co. 192
Symonds, MacKenzie & Co., Inc.

Wairton Steel Co., Div. of National Steel Corp. 24
Campbell-Ewald Co.

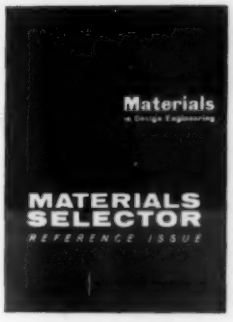
Welded Steel Tube Institute, Inc. 62
Griswold-Eshleman Co.

Yoder Co. 51
G. M. Basford Co.

* *These manufacturers advertised their products in the 1960-61*

MATERIALS SELECTOR REFERENCE DATA ISSUE

For more complete information, and application data on their lines, refer to the index of Advertisers in the Mid-November MATERIALS SELECTOR ISSUE *of* MATERIALS IN DESIGN ENGINEERING.



THE LAST WORD

What's ANYBODY'S Business Is NOBODY'S Business

by H. R. Clauser
Editor

■ There is hardly an industry or plant where materials are not now the key to meeting increasingly severe service conditions, to improving product performance, and to lowering materials or manufacturing costs. For this reason the question of how to organize to best handle the complicated materials problems of today has become one of major importance.

Up until recent years the approach to materials application was to a large extent haphazard. Traditionally, technical management was satisfied to let materials be taken care of on a hit or miss basis, or to depend on the research, engineering and production departments to solve their materials problems separately as best they could.

Unfortunately, a good many manufacturers still follow this procedure. As one respondent in a recent M/DE survey said, "Where materials are concerned it's everyone for himself," or as another engineer put it: "Materials is anybody's business."

Materials groups needed

But this approach in which dispersed and routine attention is given materials by various individuals in a number of different departments, is no longer satisfactory. It is now necessary to have a working knowledge of the properties and economics of a vast number of materials and to systematically evaluate them, to develop specifications and tests, and to work out special processing problems. This extensive and diverse materials job can only be performed efficiently by a technical group spending full time on materials activities.

There is a definite trend in industry to establish departments that serve as the control center through which all materials problems in development, design and manufacturing flow. A recent M/DE study showed that about half of the medium and large size plants in this country already have a central materials group or department. Twenty years ago only one out of ten plants had such a department.

Such groups now in many industries

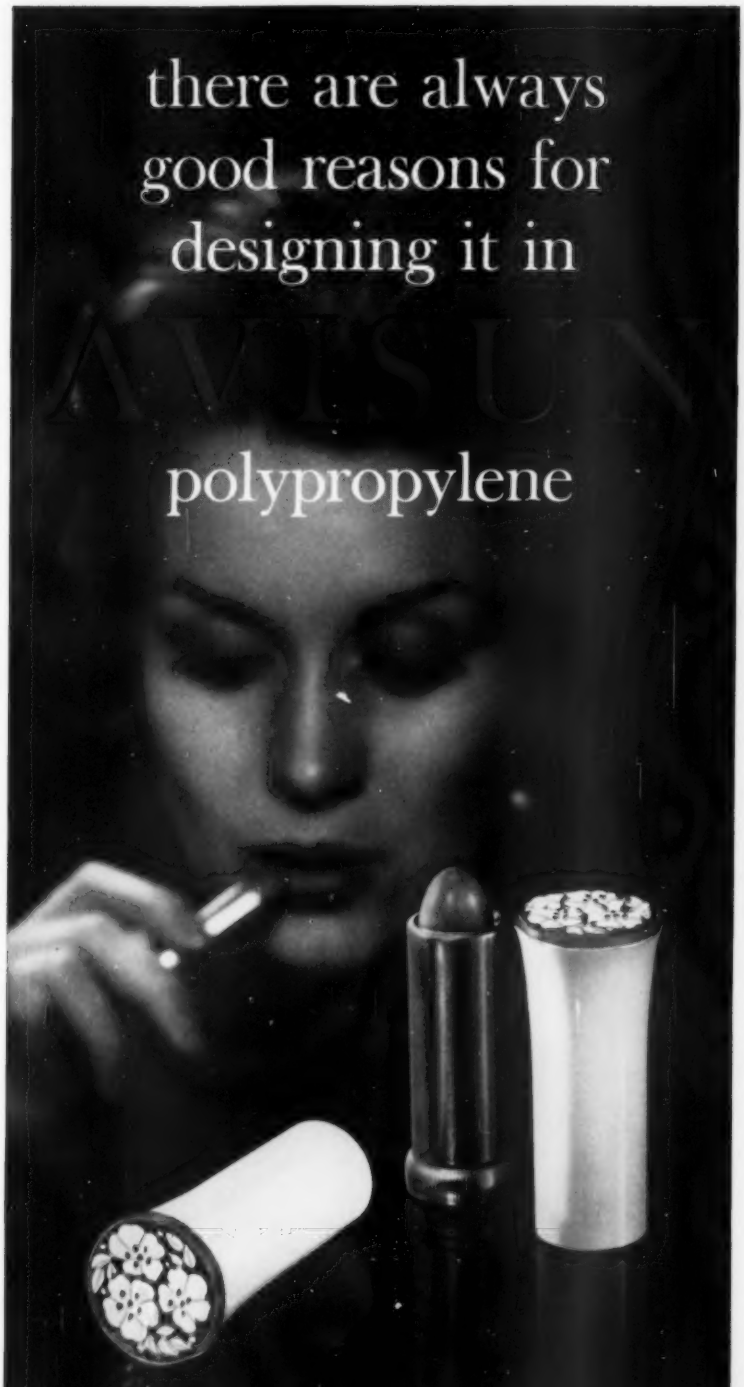
Perhaps the aerospace field has seen the most rapid growth of materials and process engineering departments. However, significant progress is being made in most other manufacturing areas. For example, as an article in this issue shows (p 117), half of the leading companies in the farm and construction equipment industry now have a materials engineering group. In subsequent issues the active growth of materials engineering in other fields will be surveyed

Experience shows that in this new era of materials a central materials group pays off. Such a group brings to bear a thorough knowledge of materials at all stages of the planning and manufacturing cycle in order to produce high quality products at the lowest possible cost.

there are always
good reasons for
designing it in

AVISUN

polypropylene



This attractive Avon Lipstick is a beautiful example of fine, multi-colored, double-shot molding. Polypropylene is unmatched for cost-saving, precision molding like this. Custom-molded by Electric Manufacturing Co., San Francisco, Calif.

in the Avon
Lipstick case

it's chemical resistance

AviSun's polypropylene #1014 proved to be the most practical material for Avon Cosmetic's new lipstick case. Economical enough for a "throw-away" item . . . yet immune to the oils and chemicals used in lipstick . . . highly resistant to scratching. Molds smoothly, with high sheen, fine detail and pleasant "feel".

Polypropylene makes better products at lower cost. No other material has this combination of properties:

1. **Heat Resistance**
2. **Toughness**
3. **Chemical Resistance**
4. **Economy**

AviSun polypropylene is being used in new applications every day—from Pulspirators to TV backs. New production facilities, now under construction, will soon be ready to meet the growing demand for this versatile new material. Send for Booklet AP-601, giving complete information on AviSun polypropylene.

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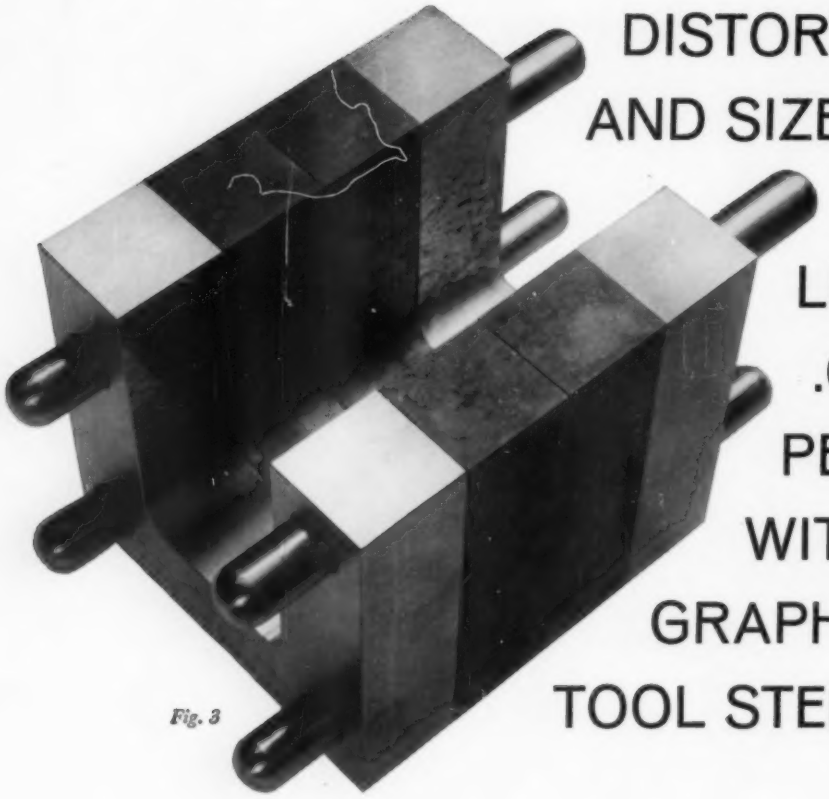

DISTORTION AND SIZE CHANGE HELD TO LESS THAN .0002" PER INCH WITH GRAPH-AIR® TOOL STEEL

Fig. 3

The test pieces pictured here demonstrate the dimensional stability of Graph-Air® tool steel that enables users to produce more intricate tools and dies.

Fig. 1 shows test piece dimensions. In the "U" shape, which is particularly sensitive to distortion in heat treating, the machining tolerance between any two holes is held to .0002". After heat treating, the specimens are fitted together by four pins having a diameter of .0003" under .500". The total assembly error under these circumstances could not exceed .0008". Distortion must be less than .0002" per inch during heat treatment for the pins to fit.

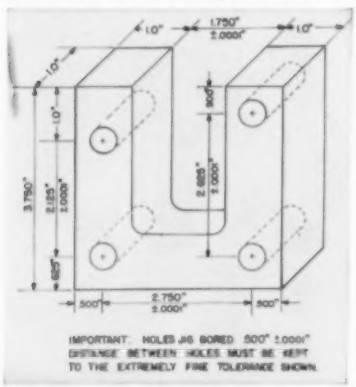

Fig. 1

The Graph-Air pieces tested were from different heats. They were air hardened from 1450°F. and double tempered at 400°F. Fig. 2 shows them as they pegged together easily, demonstrating no distortion. Fig. 3 top, shows the same specimens compared with two green, or as machined, parts. They matched perfectly again. *Graph-Air did not distort . . . did not change size.* Records indicate that no other tool steel passed this test when heat treated at its recommended hardening and tempering conditions.

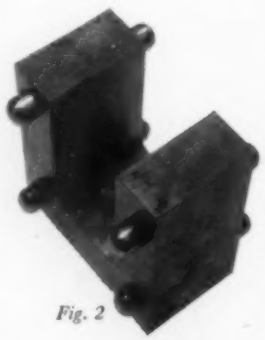

Fig. 2

Specify Graph-Air where minimum distortion and high quality are required. Solid and hollow bar sizes available. It is one of the Timken graphitic tool steels, the most stable tool steels made. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

TIMKEN®

***Fine Alloy* STEEL**

TIMKEN GRAPHITIC STEELS ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES AND CANADA

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